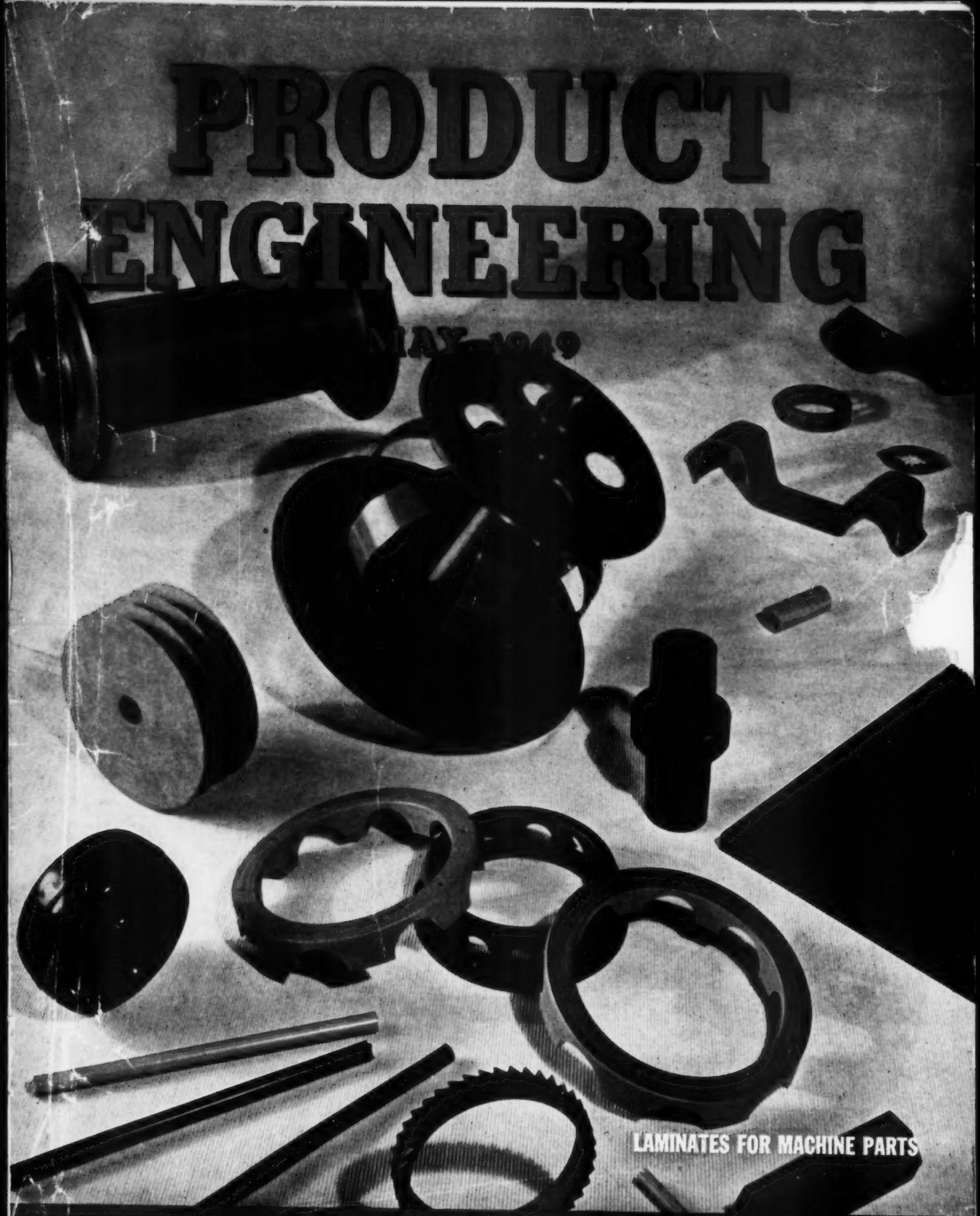
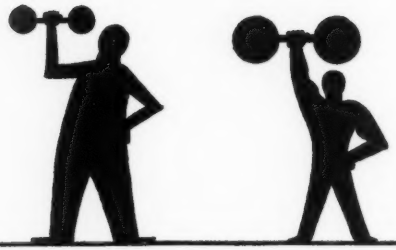
PRODUCT ENGINEERING

MAY 1954



LAMINATES FOR MACHINE PARTS



Add Load Capacity and Reduce Deadweight...

BY USING HIGH STRENGTH— LOW ALLOY STEELS Containing NICKEL

Many fabricated structures may be improved by redesigning to utilize the excellent mechanical properties of high strength low alloy steels containing nickel.

These steels provide:

1. **High strength in the as-rolled condition, permitting important weight reductions.**
2. **Excellent response to such fabricating operations as forming and welding.**
3. **Good resistance to corrosion, abrasion and impact.**

Sheet gages may be cold-formed into structural panels that assure maximum weight reductions without sacrifice of strength or safety.

These nickel alloyed steels have gained wide popularity by reducing maintenance, extending service life and eliminating thousands of tons of deadweight.

Produced under various trade names by leading steel companies, high strength low alloy steels containing nickel along with other alloying elements, have established notable performance records. Consult us on their use in your products or equipment.

* *

Over the years, International Nickel has accumulated a fund of useful information on the properties, treatment, fabrication and performance of engineering alloy steels, stainless steels, cast irons, brasses, bronzes, nickel silver, cupro-nickel and other alloys containing nickel. This information is yours for the asking. Write for "List A" of available publications.

EMBLEM OF INCO SERVICE

THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET NEW YORK 5, N. Y.

VOLUME 20 **PRODUCT ENGINEERING** NUMBER 5

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Publication Office: 99-129 North Broadway, Albany 1, N. Y. Return postage guaranteed.
Published Monthly by McGraw-Hill Publishing Company, Inc., **James H. McGraw** (1860-1948), Founder; James H. McGraw, Jr., President; Curtis W. McGraw, Vice-President and Treasurer; Eugene Duffield, Executive Assistant for Publications; Nelson Bond, Director of Advertising; Joseph A. Gerardi, Secretary; J. E. Blackburn, Jr., Director of Circulation.
Correspondence About Subscriptions should be addressed to Director of Circulation, Product Engineering, 330 W. 42nd St., New York 18. Allow at least 10 days for change of address. Indicate position and company connection on all subscription orders.
Subscription Rates: Single copies 75¢. United States and possessions, **$6 for one year, $9 for two years,** $12 for three years; Canada, $7 for one year, $11 for two years, $14 for three years; Latin American countries, $10 for one year, $16 for two years, $20 for three years; all other countries, $15 for one year, $25 for two years, $30 for three years.
Editorial and Executive Offices: 330 W. 42nd St., New York 18, N. Y. Cable address: "McGraw-Hill, New York."
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Entered as second-class matter Aug. 21, 1936, at Post Office, Albany, N. Y., under act of Mar. 3, 1879. Printed in U.S.A. Member of A.B.P., A.B.C. Copyright 1949 by McGraw-Hill Publishing Co., Inc. All rights reserved.

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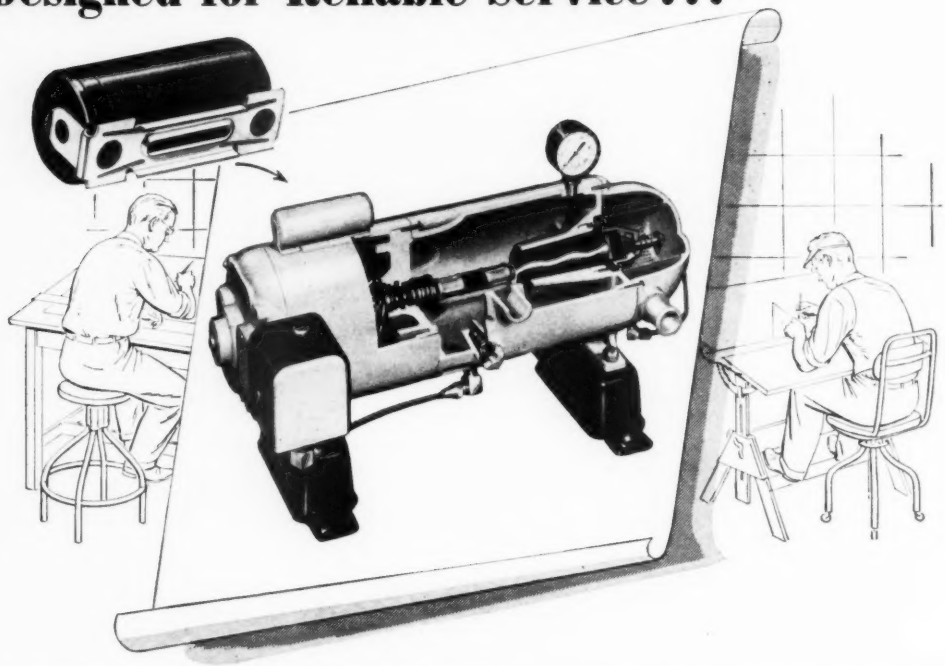

MALLORY MOTOR CAPACITORS

Mounted directly to the unit, the Mallory AC Motor Starting Capacitor is an integral part of the design of the new Robbins & Myers Shallow Well Pump. This powerful pump is driven by a capacitor-start motor and features a unique pump mechanism.

Mallory AC Capacitors, with the new mounting brackets which enable you to mount them either *on* or *off* the motor, can serve you on your designs, too. The plastic case resists moisture—insuring trouble-free operation in humid applications. The splash-proof end cap completes their insulation—protects terminals. The simple handy bracket provides firm mounting—cuts assembly time. The same quality-controlled production you find in all Mallory products, of course.

For further mechanical and electrical data—ask for Form #746-F.

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Contacts — Switches
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Resistance Welding Materials

Highlights

In this summary of technical developments, space restrictions do not allow giving complete details. Further information relating to any item can be obtained by writing to the Editor of Product Engineering.

METALLIC MATERIALS

MERCURY is getting the nod over "old reliable" aqua pura when it comes to new boilers for turbine-generators. The heat energy transfer characteristics of the vaporized metal are such that a series of turbines can be efficiently operated. One installation produces 15,000 kw and 200,000 lb of steam at 400 pounds per square inch.

PRECISION RESISTORS wound of Karma, a copper-base alloy, exhibit only a 10 percent variation from a nominal 900-ohm-per-circular-mil-foot resistance in the range from -50 to +200 C. Thermal expansion is a mere 0.000014 per degree Centigrade and tensile strength runs up to 170,000 psi after special heat treatment.

HIGHLY CORROSION RESISTANT STAINLESS steel for plastics, heavy chemicals and synthetic rubber processing equipment is now available in sheet gages from 24 to 11 and plate thicknesses from 3/16 in. up. It's a natural for pump shafts and rods, valve parts, screws, heat exchangers and exhaust fans.

FINE TUNGSTEN POWDERS with three out of every four particles measuring below 5 microns -- good news for cutting tool makers! Other forms are also in production -- sintered ingots, hot swaged rods and fine-drawn wire, the latter with diameters as small as 0.0004 in.

POWDERED ALUMINUM "cold" solder for filling dents and holes in sheet metal such as automobile bodies can, after successive applications, build up to a thickness of of one inch. Just spread it on -- and in a half hour the excess can be ground off. Advantages -- no burning of adjacent painted areas, and no breakage of the bond if slight bending occurs.

NICKEL-ALLOY WIRE used primarily for springs in high temperature applications can be had in diameters 0.060 in. and below. Coils or cut lengths of the drawn Hastelloy or Multimet material are flux-coated if attachment is by welding.

NONMETALLIC MATERIALS

SELF-CLEANING WHITE PAINT for highway and railroad signals becomes bright automatically after a rainstorm. Titanium oxide pigment does the trick by forming a chalky residue that is washed off, leaving a fresh surface.

RESIN-BONDED GYPSUM, a cold pour plastic called Palestic, is being welcomed as a strong, durable, chip resistant material for use in plaster-type mock-up castings. It sells for only five cents a pound.

A DRY LUBRICATED SURFACE is obtained with Neolube, a fast drying graphite solution. Resultant film is dust-free and permanently adherent to both metallic and nonmetallic surfaces. It's a boon to researchers as it offers an electrically conductive paint for lubricating contact points, switch blades and electronic tube prongs.

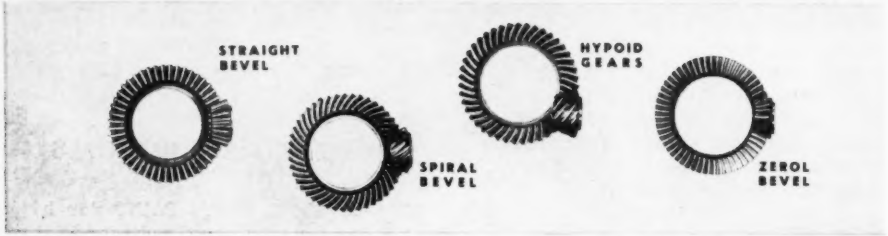
LUCITE HM-140 can be molded at temperatures about 50 F higher than those practical with the standard HM-122 heat-resistant acrylic material. Injection molding cylinder temperatures ranging from 360 to 490 F make possible the production of thin or intricate sections where fluidity is of importance.

REINFORCED PLASTIC RODS AND BARS are now in pilot plant production. Along with low moisture absorption, dimensional stability over a wide temperature range

Continued on Page 5

COMPLETE ENGINEERING SERVICE

ON YOUR BEVEL GEAR PROBLEMS



As builders of bevel gear machinery for the manufacture of straight bevel, spiral bevel, Zerol bevel or hypoid gears, we offer our services to you . . . in designing . . . in estimating production time and costs . . . in recommending the best equipment most suited to your requirements.

Utilize the complete Gleason Engineering Service

Design

SOLUTIONS OF YOUR BEVEL GEAR DESIGN PROBLEMS,

Manufacture

RECOMMENDATIONS ON THE RIGHT EQUIPMENT FOR YOUR NEEDS,

Production

ESTIMATES OF YOUR PRODUCTION TIME AND COSTS,

GLEASON WORKS

Rochester 3, N.Y.

This data sheet is provided for your convenience. You are cordially invited to submit the details necessary for our engineers to cooperate in making their recommendations to meet your Bevel and Hypoid Gear needs.

BEVEL AND HYPOID GEAR DATA

(Confidential—No Obligation)

1. Application .....

4. Gear ratio desired ..... Exact ..... Approximate .....

5. Shaft angle .....

6. Shaft offset (hypoid) .....

7. Power to be transmitted and speeds

a. Normal hp ..... at ..... rpm of pinion

b. Maximum hp ..... at ..... rpm of pinion

8. Material specifications

a. Gear .....

b. Pinion .....

9. Send essentially blueprint or sketch showing

a. Driving member and direction of rotation.

b. Means of absorbing axial thrust in both directions and for absorbing radial loads.

c. Provision for adjusting gears axially.

d. Mounting distance of each member.

e. Whether gear operates in vertical or horizontal plane.

f. Gear case limitations.

g. Method of connecting gear set to power source.

10. Service conditions

a. Type of load

Continuous ..... Intermittent .....

Shock ..... Reversing .....

Gear duration if load reversal possible: If a reversing load, indicate time-basis of operation during major portion of time .....

b. Method of lubrication

Splash ..... Forced feed ..... Other means .....

11. Make unusual conditions such as accuracy, inspection, noise and allowance .....

Date .....

Send (Name and Address To)

Company .....

Street Address .....

City ..... State .....

Attention of ..... Title .....

GLEASON Works

1000 University Avenue

Rochester 3, N. Y., U. S. A.

WHAT WE NEED to help you

For design engineering: (1) Preliminary layouts or prints of proposed bevel gear drive designs, (2) Type of drive, (3) Horsepower and speed required, (4) Type of loading (constant, intermittent or shock), and (5) Driving member and direction of rotation.

For production engineering: (1) Blueprints of your bevel gear designs, (2) Material specifications and manufacturing tolerances, (3) Quantity of gears to be produced per month, and (4) Number of working hours per month available for gear production.

Builders of Bevel Gear Machinery for Over Eighty Years

and high dielectric strength, the material has a tensile strength of 125,500 psi, a flexual strength of 131,600 psi and a torsional resistance (0.36 in. dia) of 60 inch-pounds.

TRANSPARENT GREEN GREASE with a melting point 100 F higher than other alumnium-soda type greases will be the answer to many heavy-duty lubrication problems. Manufacturer claims it's the "real thing" for automotive applications, hoists, cranes, dredging equipment and heavily loaded presses.

CARBON MONOXIDE POISONING will be on the wane if a new silver permanganate powder is put to good use. When coated on so-called carriers as the active agent, the chemical can remove all the CO from air conditioning and ventilating systems maintained at normal temperatures and humidities.

TWO PHENOLIC MOLDING COMPOUNDS reduce compression molding pressure requirements drastically. Durez 13348 absorbs shock more readily than wood-flour or flock-filled materials and takes about half the usual pressure; Durez 13527, available in brown and black only, takes a third of the normal clamping pressure. Existing press facilities can therefore handle pieces larger than in the past.

A TEN-PENNY NAIL as a center punch! Not impossible by any means -- just heat it to a cherry red (1400-2200 F), dip it in Hi-Speed-It, a mixture of various types of carbon and a catalyst, and reheat it -- a three minute operation. Critical sections of irregularly shaped parts can be hardened to Rockwell C hardnesses of 30-63 with a water paste of the material. A 0.020 in. case with reinforcing "roots" to an appreciable depth is formed -- all without loss of ductility.

PROCESSES

"MICRO-SCREEN" PRINTED CIRCUITS of either conducting or insulating material can be deposited on glass, paper, plastics -- even overlays are possible. Line widths and spacings of 0.001 in. and accuracies of 0.0002 in. are obtainable. And best of all, the combination of fine lines and highly conductive materials permits the formation of tiny inductances, resistors, potentiometers and phase shifters.

METAL FORMING PROCESS utilizes dies heated by electric current to neck, seal and upset cylindrical work. Parts are fed into the die and rotated by mechanical and hydraulic pressure. During tests, machine has necked a $3\frac{1}{2}$ in. OD tube having $\frac{1}{4}$ in. wall in six seconds.

IMAGES can be produced on special photographic emulsions by substituting pressures in the order of 10,000 psi for the usual light medium. Microscopic studies of metal surfaces can therefore be recorded, a practice prevented by the thin gelatine coating characteristic of commercial emulsions.

PORCELAIN-LIKE FINISH provides a hard, moisture and alkali resistant coating on glass, ceramics and metals such as aluminum. Baking temperature is only 420 F, a substantial reduction from the customary 1400-1900 figures. Available in eight standard colors, material can be sprayed, dipped or rollercoated.

ELECTRICAL & MECHANICAL PARTS

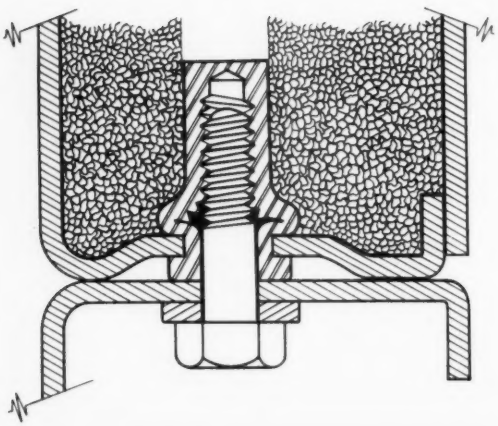
SELF-HEALING METALLIZED DIELECTRIC consists of lacquered kraft-base paper with a thin deposited zinc film. It's ideal for tiny, high-capacity electrolytics. The dielectric strength is 1,700 volts per mil.

SURPLUS MILK is being used for automobile engine filter elements! Chemically treated spun fibers made from the casein and wool form the cartridge that may become standard equipment in cars now using oil-bath air cleaners. Already the fiber filaments are used in various types of paint brushes.

POWERFUL PHOTOGRAPHIC FLOODLIGHT, producing light 7 to 15 times the intensity of sunlight on a bright day, has been designed especially for high speed photography. Motion pictures at speeds

Continued on Page 7

New, easy way to make attachments and maintain a perfect seal

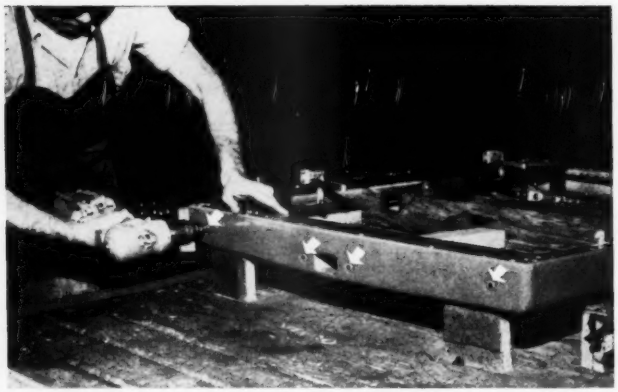


Vending machine designers use RIVNUTS to lick tough fastening problem

The designers put two doors in this vending machine, one to seal off the refrigeration unit, the other to allow adjustments during testing. This brought up the problem of how to fasten the doors together after testing, yet maintain a perfect seal at all times.

Rivnuts—the *only* one-piece blind rivet with threads—solved the problem quickly and easily! Closed-end type, $\frac{1}{4}$"-20-thread Rivnuts were used. When the Rivnuts were upset, the compression fit formed between the bulge in the shank and the head made a positive seal in the main door. And each Rivnut provided *six perfect threads* for secure screw attachment of the second door.

If your product calls for a nut plate, call in a Rivnut engineer. Chances are he can help you improve your product design and save production costs too! Write *The B. F. Goodrich Company, Dept. PE-59. Akron, Ohio.*



RIVNUTS CAN BE installed in two seconds with a new power heading tool—by one man, working on one side. Pull of tool forms bulge in shank. Threads stay clean after upsetting. Entire operation can be done *after* enameling or painting.

NEAT, CLEAN design is achieved with Rivnuts. They are available in a wide range of types and sizes, with power or manual heading tools.

GET FREE RIVNUT DEMONSTRATOR! MAIL COUPON TODAY

The B. F. Goodrich Company, Dept. PE-59

Akron, Ohio

Gentlemen: Please send me a free Rivnut demonstrator that shows how Rivnuts work.

Name_____ Title_____

Company_____

Address_____

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RIVNUTS

The only one-piece blind rivet with threads

up to 9,000 individual pictures a second are possible. Light output is 75,000 footcandles as compared with the 50-foot-candle level existing in better indoor lighting systems.

CARTRIDGE-TYPE FUSES are slow to "blow" and low in current-carrying capacity when compared to the new "Amp-Traps."

"Blowing" action is five times faster and current capacities go to 4,000 amp. The secret -- a silver link that melts to a non-conducting vapor and quartz sand that absorbs heat emitted from the arc.

ELECTRIC SWITCH for electric heating pads is operated by fingertip touch, not sight, with one button for low heat, a pair for medium, and a set of three for high heat. Reversing a tiny rotor cuts off the current.

A SYNCHRO MOTOR weighing one pound is twice as accurate as standard 5- and 10-lb models. Unit operates on 400 or 60 cycle current and is used to transmit angular position data in Army Ordnance fire control mechanisms.

ROBOT HANDS are doing the work of humans

inside shielded atomic ovens at the Argonne National Laboratory. Researchers control seven different movements of the two mechanisms remotely and observe operations by watching a system of mirrors. Device is called the "master slave manipulator."

TESTING

WHAT DO YOU DO when you want to measure the thickness of a translucent sheet of glass, quartz and plastics? The Opti-Mike, an instrument that functions on the optical-depth-of-focus principle, is the answer. It's accurate to 0.001 in. and can measure flat, concave, or convex surfaces, whether smooth, ground or patterned.

HUGE TRACTION DYNAMOMETER is a 60-ton, 1,000 hp, electric-drive, 16-wheel, combination of truck and dynamometer, nearly 50 ft long, 11 ft wide, and 12 ft high. Its equipment includes 19 electric generators and instruments that record drawbar pull, acceleration, track speed, engine speed, and fuel flow of tested vehicles, whether wheeled or tracked and regardless of size.

THE FINGER METHOD for determining the "dust-free" time of a paint film may not have to be used much longer. A simple tester imitates the ordinary salt shaker by causing calcium carbonate particles to fall at regular intervals on the film. When the "dust medium" no longer adheres, film is considered dust free.

PARACHUTES will soon be tested on the ground under conditions simulating speeds of 500 mph. The USAF Materiel

Command is erecting a 120 ft steel tower around which test chutes will be pulled by a 2,900-hp variable frequency drive. A firing device will release the chute from a streamlined rotating nacelle that acts much like the familiar fly-ball governor.

THE 9TH ANNUAL CONFERENCE on Weights and Measures held at Paris decided to toss out the term "Centigrade" and to use the word "Celsius" in its place. National Bureau of Standards has fallen in line and is applying the new designation when stating values for the International Temperature Scale.

PRODUCTS

SMALL FIRE EXTINGUISHER, known as the "1-2-3," has an over-all length of 6 in., a diameter of 1½ in., and a total weight of 13 oz. Discharge nozzle is ½ in. long, beaded near the tip to produce a conical discharge pattern for optimum coverage. No pumping mechanism is required since the methyl bromide and freon contents are self-expelling. Unit can be used for all types of fires.

AN "ERECTOR SET" for designers of servo mechanisms. Equipment consists of a

slotted metal board and a variety of standard servo components. It can be adjusted for unlimited combinations, using the board as a base. Set provides a compact laboratory in which to test new servo ideas or to arrive at a desired result by the cut-and-try method.

Rolling silicon bronze to the exact diameter before welding

Resistance welding of longitudinal seam

The bottom is resistance-welded to the shell

REVERE SILICON BRONZE IN RE-DESIGNED EXTINGUISHER

Everyone is familiar with the 2½ gallon fire extinguisher that is operated by turning bottom up. It is to be found in almost every factory, office and school. With it, countless fires have been put out, lives, property, jobs, money saved. Such a standard product tends to be taken for granted; most people naturally assume that it has reached its final perfection. Not so American-LaFrance-Foamite Corp., which some time ago decided to re-design its Alfco extinguishers in the light of the newest technological developments. To the user, the new extinguishers are definitely improved, being free from rivets, 4¼ pounds lighter, and much more handsome. To the company, the product has been bettered in other ways, and is more efficiently produced.

Working out this extensive program required careful consideration of the relationships between design and materials, and materials, methods and machines. Alfco wished to abandon rivets and go to seam welding, among other things. Silicon bronze was selected as the material, because that can be easily resistance-welded, possesses strength of mild steel together with the corrosion resistance of copper. Revere and Alfco got together and jointly set up the time, temperature and pressure requirements for clean, sound welds. It was also necessary for Revere to establish the proper tempers for the body sheet so that it will more than withstand the Underwriters' pressure test, but still be formable into a cylinder with beads that locate the top and bottom domes. Similarly, tempers had to be selected for the sheet to be drawn into the domes. In all these and other activities the accumulated knowledge and experience of the Revere Technical Advisors, the welding section of the Research Department and of three Revere mills were used. Finally, the Research Laboratory tested the first production extinguishers to make sure that annealing practices were adequate.

Revere considers this an outstanding example of the benefits possible when a manufacturer and supplier collaborate on mutual problems. You are invited to consider Revere not only as a source of nonferrous metals, but of know-how in their selection and fabrication.

REVERE

COPPER AND BRASS INCORPORATED

Founded by Paul Revere in 1801

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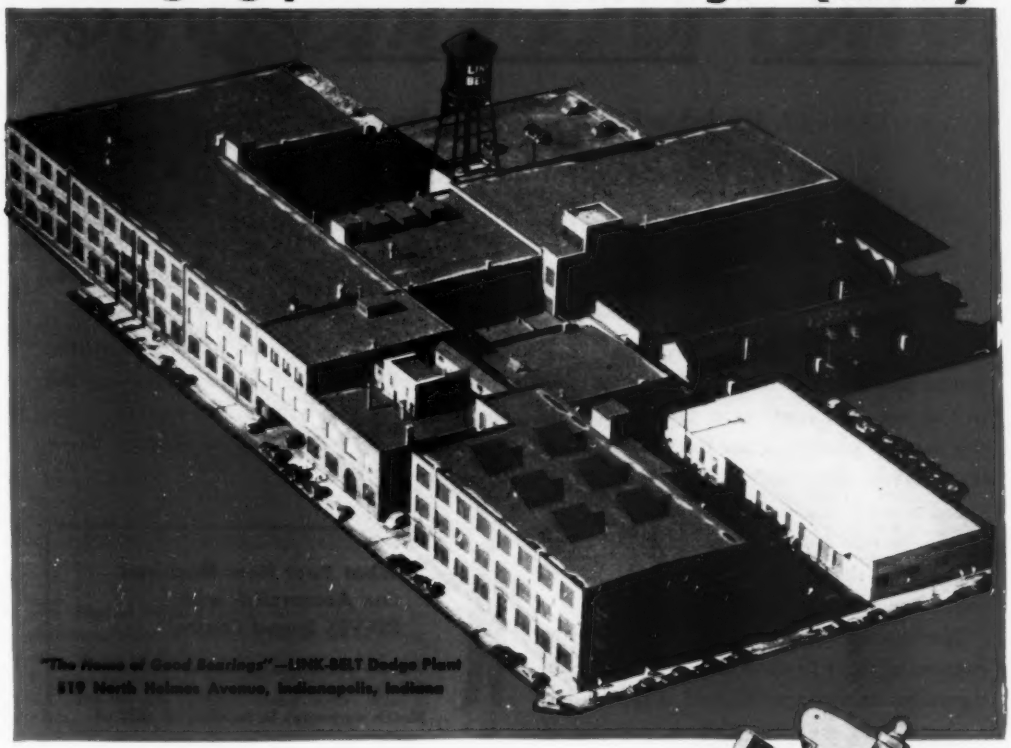
• • •

Mills: Baltimore, Md.; Chicago, Ill.; Detroit, Mich.; Los Angeles and Riverside, Calif.; New Bedford, Mass.; Rome, N. Y.

Sales Offices in Principal Cities, Distributors Everywhere.

The new Alfco Extinguisher, made by American-LaFrance-Foamite Corp., Elmira, N. Y.

One LINK-BELT Plant devoted *Solely* to bringing you better bearings—*Quickly*



"The Home of Good Bearings"—LINK-BELT Dodge Plant
519 North Nelson Avenue, Indianapolis, Indiana

Meeting industry's ever-increasing demands for ball and roller bearings that offer the desired combination of free-rolling action, self-alignment, and long life is no small-sized job.

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From the receipt of housing castings furnished by sister plant foundries to shipment of finished mounted bearings, alert design engineers, skilled craftsmen and the most modern bearing production machinery work hand-in-hand to turn out the bearings that enable users to TURN SHAFTS EFFICIENTLY.

Cut-away view of Series 200 Ball Bearing Pillow Block

LINK-BELT COMPANY

Indianapolis 8, Chicago 9, Philadelphia 40, Atlanta, Dallas 1, Minneapolis 5, San Francisco 24, Los Angeles 33, Seattle 4, Toronto 8. Distributors in Principal Cities

11,387

LINK-BELT — *Ball and Roller BEARINGS*

ONLY REEVES *Gives*

1. Variable Speed Transmission. 2. Vari-Speed Motor Pulley. 3. Vari-Speed Motodrive. Each with its own specific field of application to assure accurate, infinite speed control for every type and make of driven machine.

Today, more than 2,100 different makes of production machines offer REEVES Speed Control as standard equipment. One reason for this marked preference for REEVES is the fact that REEVES, *alone,* makes a *complete* line of speed control units from which the machine designer and builder can choose the unit which measures up in *every* detail to the specialized requirements of *each individual machine.*

The REEVES line of variable speed drives consists of three basic units . . . each one designed for its own specific field of application . . . but all incorporating the same time-tested REEVES operating principle, proved in more than 265,000 installations in virtually every industry. Each of these three basic units, in turn, is available in a wide range of designs, sizes, capacities, speed ratios and controls.

In selecting the speed control equipment that will be standard equipment on your machines, make sure you choose the unit that will provide *exactly* the right speed for every operation and every operator under every changing condition . . . *make sure you choose* REEVES!

Call upon the REEVES field engineer nearest you for assistance in studying your particular speed control problem and selecting the correct unit. Also write for the catalog giving full details on the *complete* REEVES line—No. K5-450A.

What Your New Machines Can Accomplish with REEVES Speed Control

1. **Handle more sizes, shapes and materials.**
2. **Match variances in number or skill of operators.**
3. **Compensate for change in consistency, density or viscosity of materials in process.**
4. **Accurately control heating, baking, drying, cooking or chilling time.**
5. **Maintain uniform peripheral speed (or tension) on decreasing or increasing diameters.**
6. **Maintain uniform pressure, weight, liquid level, temperature and other variable elements.**
7. **Regulate conveyor speeds—even to fractions of an inch per minute.**
8. **Synchronize all working parts—of one machine or machines operating in series.**

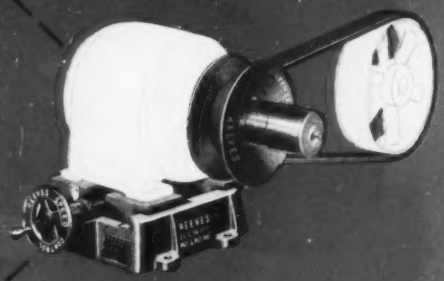
REEVES PULLEY COMPANY • COLUMBUS, INDIANA

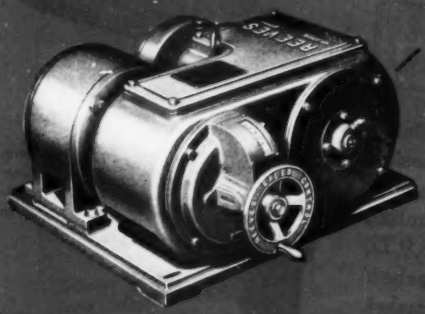
Recognized Leader in the Specialized Field of Speed Control Engineering

you a "choice of 3"*

* **Transmission** (left), extremely rugged in construction, is especially desirable for installations where the demand is for heavy-duty service, higher horsepower output, wide speed range, automatic control, etc. "Internal operating parts" ideal for incorporation within the machine framework as standard equipment. Transmission provides infinite, accurate speed flexibility over a range of 2:1 to 16:1. Sizes—fractional to 87 hp.

* **Motor Pulley** (right), most practical in installations calling for economy, limited speed range, ease of installation, low horsepower output, etc. Provides an instantly variable speed drive within 4:1 ratio for any constant speed motor. Sizes to 10 hp.





* **Motodrive** (left), ideal for installations indicating compactness, low output speeds, etc. Combines motor, speed varying mechanism and reduction gears in single unit. Speed variations 2:1 to 6:1 inclusive. Sizes to 20 hp.

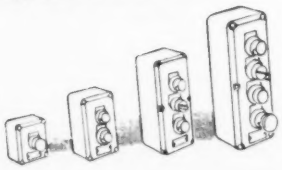
ACCURATE • VARIABLE

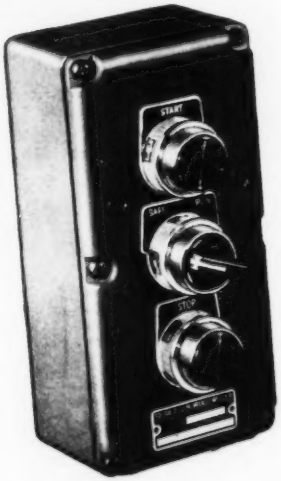
Reeves Speed Control

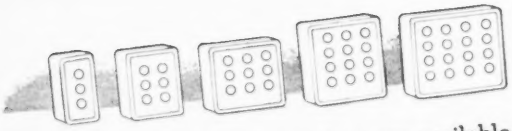
GIVES THE RIGHT SPEED FOR EVERY JOB!

Oil-Tight PUSH BUTTONS

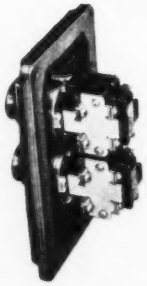
AVAILABLE AS COMPLETE STATIONS







• Oil-tight pushbutton stations are available with from one to sixteen units. Type TY design (1,2,3 and 4 units) have die cast enclosure with oil-resistant cover gasket which seals mounting holes to prevent leakage. Type M design (3,6,9,12, 16) units have cast aluminum box with heavy sheet steel cover plate and oil-resistant cover gasket.



Type TZ oil-tight stations for flush mounting are also available with from 1 to 4 units.

SQUARE D COMPANY

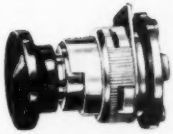
DETROIT • MILWAUKEE • LOS ANGELES

SQUARE D COMPANY CANADA LTD., TORONTO • SQUARE D de MEXICO, S. A., MEXICO CITY, D.F.

designed for Machine Tool Service

OR AS INDIVIDUAL UNITS

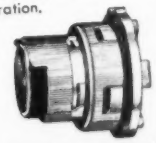
ANY OPERATOR



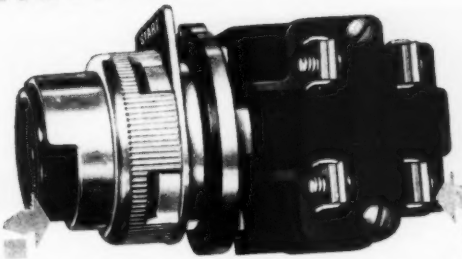
Momentary Contact Mushroom Button, Red or Black.

Selector Switch, 2 Positions or 3 Positions with 4 different operating cams.

Selector Switch with slot to discourage unauthorized operation.



Selector Pushbutton combining Selector Switch and Pushbutton functions in a single unit.



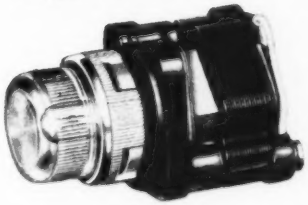
Operators Separate from Blocks—Maximum Flexibility —Minimum Stock

√ Proven oil-tight and coolant-tight by severe tests involving millions of operations.

√ Much more compact, they require substantially less panel and back-of-panel space than previous designs.

√ Extra flexibility. A virtually unlimited number of combinations can be obtained from standard units.

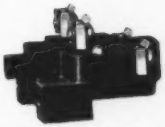
New Pilot Light has Important Features



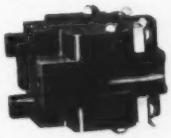
• Wide angle visibility—Unusual brilliance—Integral transformer—Six-volt lamp filament withstands shock and vibration which frequently cause failures of higher voltage filaments—Bayonet-type socket prevents lamp loosening under severe shock or vibration.

Write for Bulletin 9001 Type T. Address SQUARE D COMPANY, 4041 N. Richards St., Milwaukee 12, Wisconsin.

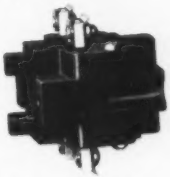
WITH ANY BLOCK



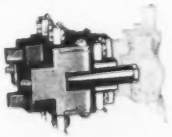
Single Pole N.O. and N.C. Contacts.



Duplex N.O. Contacts.



Duplex N.C. Contacts.



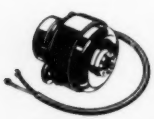
Duplex N.O. and N.C. Contacts with stems for tandem operation with another block.

F.E. Myers assures

SAYS MR. C. GINN, Vice President and General Manager of the F. E. Myers & Bro. Co., one of the leading water pump manufacturers: "We regard the use of standard motors for pump and water system service as an important advantage to our customers. Motor exchange plans, made possible by the use of standard motors, enable the user to get his pump back in operation with a minimum of delay. Any interruption of water supply is serious and, if extended, may be disastrous, especially to farmers. The use of standard motors and consequent ease of replacement and service is a big talking point for our products."

More for your money with

STANDARD G-E Fractional-Horsepower MOTORS



Unit-Bearing Fan

Washing Machine

Oil Burner

Machine Tool

Gas Pump

Hermetic Refrigeration

customer satisfaction WITH GENERAL ELECTRIC STANDARDIZED Fractional Horsepower MOTORS

Here's the motor that F. E. Myers & Bro. Co. says helps make customer service a strong selling tool—the G-E General Purpose Capacitor-Start Motor. It is widely used on water-pumping systems, commercial refrigeration and air conditioning compressors, industrial air compressors, material handling equipment, motorized tools, commercial laundry equipment . . . wherever high starting torque, long life, and minimum servicing are required.

The General-Purpose (Type KC) has an open (dripproof) enclosure, 40 C rise, and a solid base. It is immediately available in ratings from $\frac{1}{6}$ to 1 hp; 3450 to 1140 rpm; constant speed; single-phase, 60, 50, or 25 cycles. For more details, call or write your nearest G-E sales office. *Apparatus Dept., General Electric Company, Schenectady 5, N. Y.*

THEY'RE QUIET . . . AND COMPACT . . . AND RUGGED

Sleeve bearings are bored to a mirror-like finish for long-lived, quiet operation. Starting is snappy, yet quiet.

Sound design and the use of modern insulating materials has packed a lot of motor into a little space.

The sturdy end shields, rigidly support the bearings and the frame itself is all-steel, rolled and machined.

GENERAL ELECTRIC

Belted Fan

Coal Stoker

Jet Pump

Shaft-Mounted Fan

Sump Pump

General Purpose

Haskelite Materials

OPEN NEW HORIZONS IN PRODUCT DESIGN

Designers and manufacturers find the unique characteristics of Haskelite Structural Materials offer many advantages over wood, metal or other materials they are replacing in so many products . . . and find they help build products that look better, perform better and sell faster.

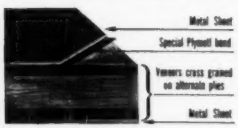
SALES BUILDING APPEARANCE: In the group of Haskelite Materials, are lightweight metal faced plywoods with smooth, ripple-free surfaces . . . metal backed veneers of beautiful woods that may be fabricated as easily as sheet metal . . . any one will help add new eye appeal to your products.

LIGHT WEIGHT — GREAT STRENGTH: The *rigid strength-to-weight* ratios of certain Haskelite Materials are unmatched by even the newest of light alloys.

SIMPLIFIED CONSTRUCTION: Haskelite materials are worked with simple tools. Their use often eliminates numerous or complicated framing members — cutting deadweight and saving time. Write for bulletin SC-47.

Plymetl *

A lightweight, high quality plywood plaque with light gauge metal sheets permanently bonded to one or both sides. This material has a high *rigid strength-to-weight* ratio, is sound deadening, fire retardant, and high in insulating value. Its flat, smooth metal surfaces take and retain a beautiful finish, free from distorting highlights.



Ornametl *

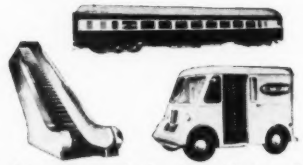
A thin veneer of choice wood is bonded to thin gauge sheet steel. Ornametl is readily adaptable to production methods and equipment used for fabricating sheet metal. It may be stamped, pressed, or rolled to shape. It can be sawed, drilled, punched, and fastened by welding, nailing, or with metal screws or rivets.

Plymold

This process permits molding to either simple or compound curvatures, depending upon the material. Fine plywood and other composite materials such as Haskelite Plymetl and Plastiply have been molded by this process in volume quantity.

*T. M. Reg.

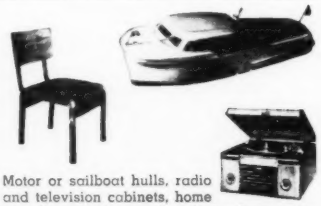
TYPICAL USES



Escalator side panels, interior finish for railway passenger cars. Truck and trailer body panels. Table tops, restaurant counter tops, etc.

"ESCALATOR" — T. M. Reg. by Otis Elevator Company

Office furniture, station wagon side panels, interior finish for passenger cars, house trailers, home or office interiors, and appliances, clocks, magazine racks, decorative ornaments, etc.



Motor or sailboat hulls, radio and television cabinets, home or office furniture, aircraft fuselage, wing and tail assemblies, etc., in volume quantities.

HASKELITE T.M. Reg.

structural materials for men who build better

HASKELITE MANUFACTURING CORP. DEPT. PE GRAND RAPIDS 2, MICHIGAN

New York Chicago Detroit Philadelphia Los Angeles St. Louis

Canada: Railway & Power Engineering Corp., Ltd.

Build-in **Veeder-Root** Counters and Build Up Your Product's Sales!

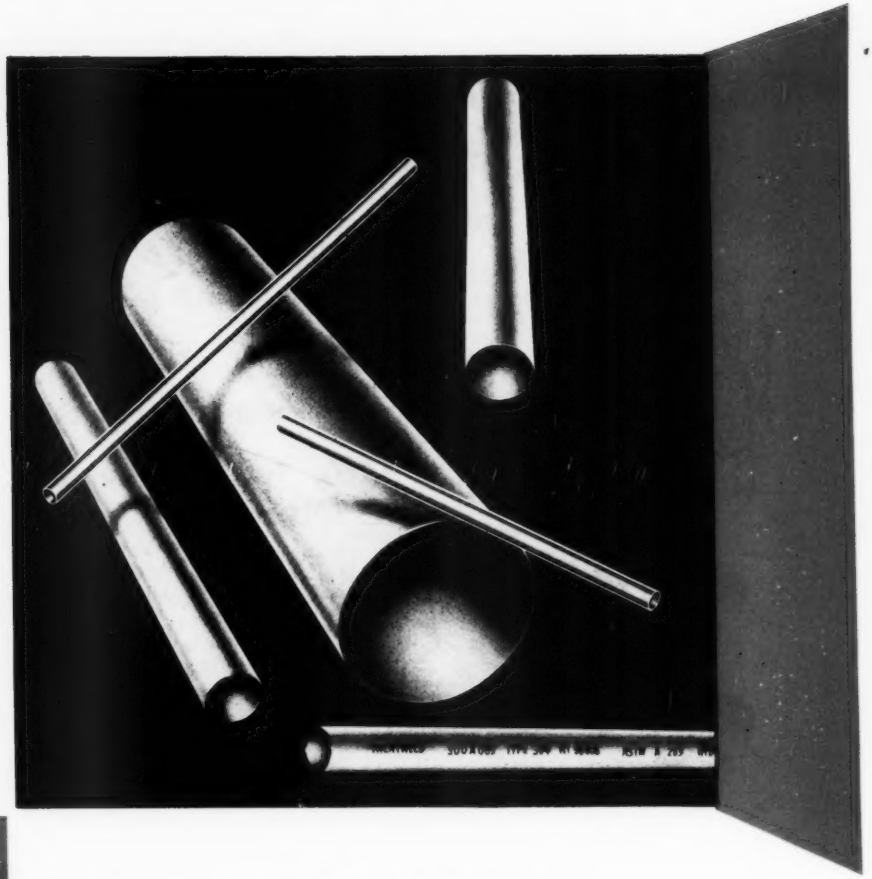
Veeder-Root Counters can be *engineered into the design* of almost all types of machines, from addressing to vending. These counters do countless things, depending on the application and its peculiar requirements. They add new usefulness to a product—new merchandising appeal. They help prove the product's service guarantee, sometimes even help the customer pay! They help prevent errors, delays, shortages, overruns, waste, danger. They help provide an equitable basis for wage payment and incentives. Or they can help to co-ordinate production and work-schedules more closely—as well as anticipate maintenance needs.

Those are a few of the jobs being done every day by Veeder-Root *Count*rol. *How?* That's for us to tell *you!* So if you want to count your way to greater sales and profits—*write.*

VEEDER-ROOT INCORPORATED, HARTFORD 2, CONNECTICUT

In Canada: Veeder-Root of Canada, Ltd., 955 St. James St., Montreal 3.
In Great Britain: Veeder-Root Ltd., Kilspindie Rd., Dundee, Scotland.

Veeder-Root COUNTERS



TRENT

STAINLESS STEEL TUBING

TRENT TUBE COMPANY

Subsidiary of CRUCIBLE STEEL COMPANY OF AMERICA

General Office and Plant • EAST TROY, WIS.

If stainless steel tubing can solve your problem, then Trent Tubing is your answer — for Trent is *the only mill in the country* with facilities for making stainless steel tubing in sizes ranging from ⅛" O. D. to 30" O. D. with wall thicknesses varying from 0.005" to 0.172".

Think what this means to you! Between these limits lies a designer's paradise — a complete range of sizes, finishes and analyses to meet every product and process need, PLUS engineering and metallurgical assistance for the one application in a thousand that falls outside of Trent's normal production.

Yes, when you plan with Trent you can give free rein to your imagination — you may design for corrosion, heat, abrasion, or simply sanitation, with the knowledge that your precise requirements can be met. Your inquiries on Stainless Steel, Inconel, or Monel Tubing will be welcomed. Ask for the Trent Data Bulletin and indicate the application you have in mind.

free reins for your imagination

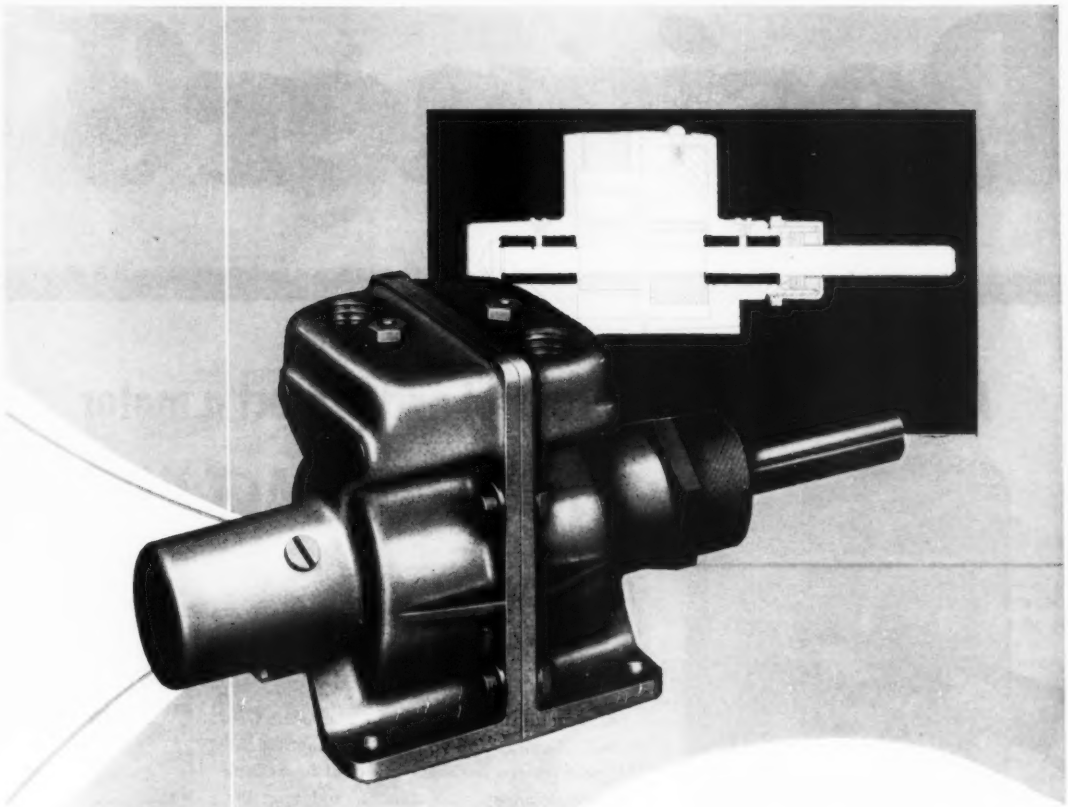
GRAPHITAR BEARINGS

CARBON-GRAPHITE

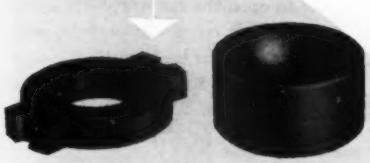
keep ECO gearless pump operating without lubrication

Graphitar bearings installed at both ends of the main pump shaft are helping the ECO Gearless Pump to operate without maintenance for long periods of time in scores of pumping jobs. ECO Gearless Pumps are designed for operation with gasoline or electric motors to handle a wide range of liquids and viscous fluids. The two Graphitar Bearings permit smooth and quiet operation of the pump, and because they require no lubrication, they eliminate the possibility of contamination by oils or greases of the liquid being pumped. Graphitar bearings operate efficiently at speeds from 300 to 3400 RPM at which the pump shafts are designed to operate.

THE UNITED STATES GRAPHITE COMPANY



GRAPHITAR

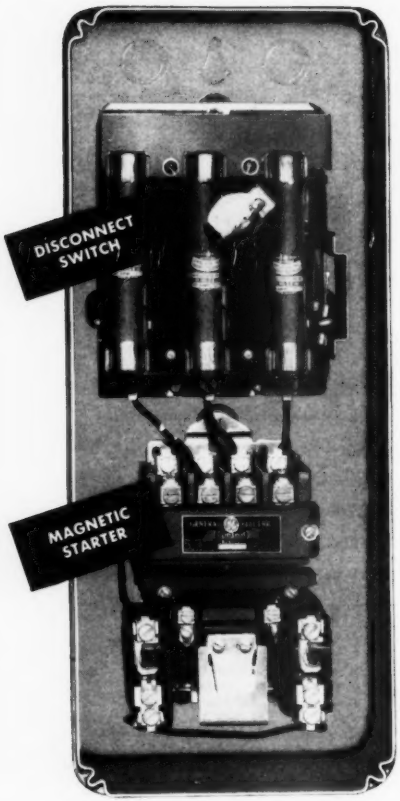


Graphitar has helped scores of manufacturers solve an otherwise difficult manufacturing problem because of its many unique and valuable characteristics. Graphitar is extremely light-weight — lighter than magnesium — yet it is mechanically strong and resistant to wear. Graphitar is chemically inert and unaffected by temperature extremes. It is ideal for seals, rings, pistons, bearings and bushings — it can be produced in any practical size and shape with tolerances as close as .0005" in small sizes. An inquiry or a sketch of your product will give our engineers an opportunity to show you where Graphitar parts may improve mechanical performance and save you money. We have a catalog which we will gladly send you.

DIVISION OF THE WICKES CORPORATION • SAGINAW, MICHIGAN

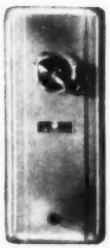
Designer's

ALL YOU NEED to control and protect a motor



IN ONE COMPACT UNIT

ALL-NEW COMBINATION STARTER



All new all the way through! That's the General Electric full-voltage combination a-c motor starter, designed and built for reliable operation, easy maintenance, and long life. A compact, easy-to-mount unit, it combines contactor and its overload relays with disconnect switch and fuses. You get both motor overload *and* short-circuit protection!

Cuts installation time Starter and disconnect switch are wired together to be installed as one unit. No extra time or money need be spent on interconnections.

Saves space This one unit takes up less space than separately mounted devices. Its streamlined case means improved machine appearance.

Increases personnel safety New rotary-action disconnect switch makes it impossible to open the cover without opening the circuit. Switch handle and cover can both be padlocked to insure complete protection of personnel.

Made in NEMA sizes 0, 1, 2, and 3 for a-c motors up to 50 hp. Get the full story in Bulletin GEA-5156.

GENERAL ELECTRIC

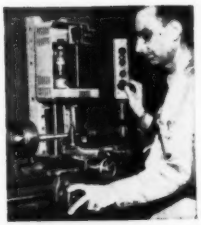
Digest GE PRODUCT HIGHLIGHTS

MEASURES THROUGH THICK OR THIN!

To make sure coatings or linings on production parts are not so thin as to be insufficient, nor so thick as to be wasteful, use a General Electric thickness gage. It quickly, easily measures any non-magnetic material on magnetic iron or steel without marking the finished surface. Simply place the gage head against one side of the coated surface, and an instrument indicates the thickness. Three types available cover a range from 0.00005 to 0.750 inch. Shown is Type A, measuring copper plating thickness on electronic tube parts. See Bulletin GEC-319.

GIVES LOW-COST SPEED ADJUSTMENT!

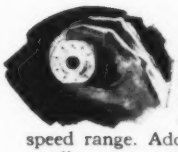
Here's the abridged edition of General Electric's Thy-mo-trol drive—the low-cost Type H1. Utilizing a simplified half-wave electronic circuit, it provides stepless speed adjustment for constant-torque loads over a 20 to 1 speed range from 1725 to 86 rpm. Where close speed regulation and full torque at low speeds are required—but not all the refinements of conventional Thy-mo-trol—the H1 offers an ideal drive at a lower price. Ratings up through $\frac{1}{2}$ hp are available. See Bulletin GEA-5179.



COVERS 90 TESTING DEVICES!

Want a quick round-up of data on specialized testing and measuring devices? This comprehensive, illustrated booklet reviews more than 90 modern General Electric equipments for that purpose. Included are weights, dimensions, and prices, plus references to individual publications containing more detailed information. Convenient grouping under eleven "use" headings lets you locate specific items of interest quickly and easily. See Bulletin GEA-639.

Dial Service for Motor Speeds



Just turn the dial on this General Electric Type ACA adjustable-speed induction motor for quick speed changes, infinitely adjustable over a 3 to 1, 6 to 1, or 20 to 1 speed range. Add a 10-foot flexible cable (for the smaller motor ratings) and you can still dial your speeds. With a pilot motor instead, you can dial from *any* distance.

Compact and self-contained, the ACA is only slightly longer than a constant-speed motor of comparable rating. Standardized NEMA dimensions are used to avoid any new mounting problems. Ratings from 3 to 75 hp are available in Tri-Clad open (dripproof) construction. See Bulletin GEA-4883.

General Electric Company, Section F668-73
Apparatus Department, Schenectady 5, N. Y.
Please send me the following bulletins:

- ( ) **GEA-639—Testing and measuring equipment catalog**
- ( ) **GEA-4883—ACA adjustable-speed motors**
- ( ) **GEA-5156—Combination starters**
- ( ) **GEA-5179—Type H1 Thy-mo-trol drives**
- ( ) **GEC-319—Thickness gages**

CONSULT YOUR McGRAW-HILL ELECTRICAL CATALOG FOR PRODUCT ENGINEERS! You'll find "everything electric" for machinery manufacturers in the General Electric section.

Name .....

Company .....

Street .....

City ..... **State** .....

Another outstanding J&L development—

J&L "E"

FREE-CUTTING STEEL

A new bessemer

SCREW STOCK

with proved machinability ratings as high as 170!

•Backed by 50 years of leadership in the field of free-machining, cold-finished steels.

•Proved by exhaustive field testing.

•J & L "E" Free-Cutting Steel is made in *three* grades: E-15, E-23 and E-33, each within the composition limits of the standard bessemer screw steels and with similar tensile properties.

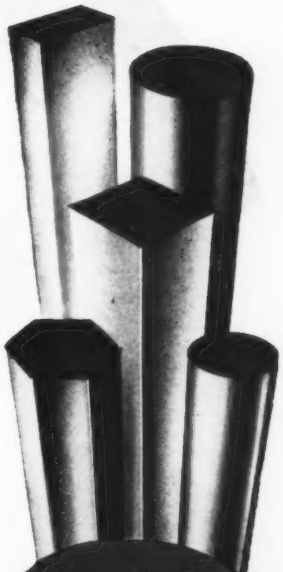
Note the following equivalents:

E-15 - equivalent standard grade, B-1111
E-23 - equivalent standard grade, B-1112
E-33 - equivalent standard grade, B-1113

J&L STEEL

Forty-five independent machine shops, throughout the metal-working industry, have tested over *6,100 tons* of J & L "E" Steel in more than 100 applications. These shops report:

- **BETTER MACHINE FINISH**
- **LONGER TOOL LIFE**
- **HIGHER SPEEDS**
- **MACHINABILITY RATINGS UP TO 170**
- **BETTER RESPONSE TO FORMING AND COLD WORK**
- **HIGHER MAGNETIC PERMEABILITY**



All standard sizes and shapes are available.

For 50 years J&L has led in the development of free-cutting, cold-finished steels—both bessemer and open-hearth. Every new J&L steel introduced in this field has been a major contribution toward the lowering of the unit cost of machined steel parts. Now we offer you J&L "E", a bessemer grade steel with distinctly greater free-cutting efficiency.

During the development of J&L "E" Steel, at least four years were spent proving its qualities, in the field, under a great variety of machining conditions. In the course of our investigations, J&L metallurgists have accumulated considerable data and a large number of case histories. Therefore, we say with assurance that J&L "E" free-cutting steel opens the door to new production economies you never thought possible.

You will want complete information on this latest J&L steel development. Let us discuss the money-saving possibilities of J&L "E" Steel with you. The coupon is for your convenience.

Jones & Laughlin Steel Corporation
409 Jones & Laughlin Building
Pittsburgh 19, Pa.

I should like to have more information on J&L "E" Free-Cutting Bessemer Screw Stock. Please have your representative call.

Name_____

Title_____

Company_____

Address_____

JONES & LAUGHLIN STEEL CORPORATION

From its own raw materials, J&L manufactures a full line of carbon steel products, as well as certain products in OTISCOLOY *and* JALLOY (*hi-tensile steels*).

PRINCIPAL PRODUCTS: HOT ROLLED AND COLD FINISHED BARS AND SHAPES • STRUCTURAL SHAPES • HOT AND COLD ROLLED STRIP AND SHEETS • TUBULAR, WIRE AND TIN MILL PRODUCTS • "PRECISIONBILT" WIRE ROPE • COAL CHEMICALS

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...for mass

KRISPER BOX, *molded by Tri State Plastic Molding Co., Henderson, Ky. Distributed by Ruzak Industries, Inc., 101 W. 37th St., New York, N. Y.*

JEWEL BOX, *molded and distributed by Commonwealth Plastics Inc., 98 Adams St., Leominster, Mass.*

Styron's range of formulations enables you to broaden your variety of product applications. Whether you require light stability, unusual clarity, impact strength, or rigidity, you'll find it in a Styron formulation. For Styron (Dow polystyrene) is a real career plastic . . . a material aid to craftsmanship.

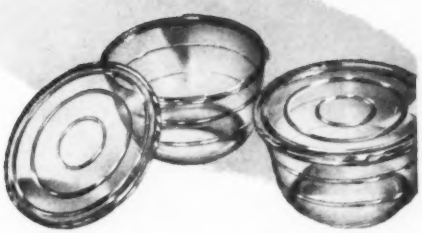
More and more products—from housewares, toys and jewelry to radio and refrigerator parts—are taking on new beauty, serviceability and economy when they're molded of Styron. Sparkling clear or brilliantly colorful, Styron imparts the feeling of luxury—at low cost!

The unique adaptability of Styron to mass production moldings at low unit cost means increased design freedom for you. Contact your nearest Dow office today and remember, there is a Styron formulation for every job.

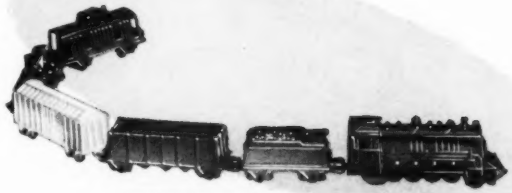
Plastics Division T-27 • THE DOW CHEMICAL COMPANY • MIDLAND, MICHIGAN

CURTISS CANDY DISPENSER, *molded by Federal Tool Corp., 412 North Leavitt St., Chicago, Ill. Distributed by Curtiss Candy Company, Belmont Ave., Chicago 13, Ill.*

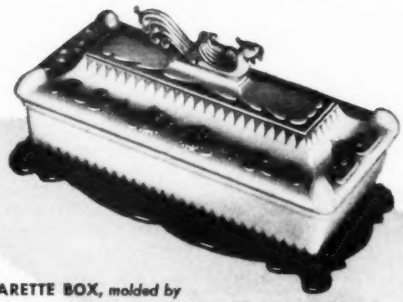
production



BABY STOWAY DISH, *molded and distributed by Southern California Plastic Company, 1805 Flower St., Glendale 1, California.*



"CHIEF" FREIGHT TRAIN, *molded and distributed by Nosco Plastics, Erie, Pa.*



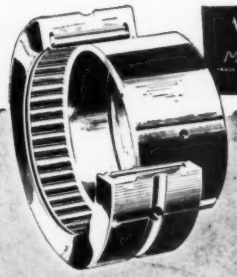
CIGARETTE BOX, *molded by Amos Molded Plastics, Edinburg, Indiana, and distributed by Alden Plastics Company, Fifth Avenue Bldg., New York, N. Y.*

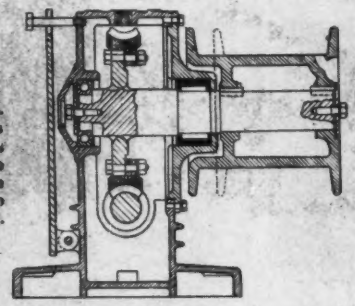
DOW
plastics

design anti-friction efficiency into out-moded plain bearing applications

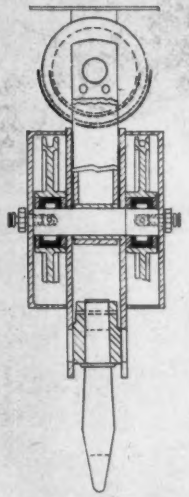
THE *MULTIROL* WAY

When design demands maximum load capacity in limited space . . . plus top anti-friction performance . . . get results with MULTIROL SE Series full type roller bearings. MULTIROL SE Series bearings afford definite performance advantages over friction bound plain bearings. They increase machine efficiency with the kind of smooth precision operation that requires less maintenance for longer machine life — power requirements are less for MULTIROL bearing equipped machinery. SE Series construction is simplified . . . no loose or welded in roller retaining washers . . . lubrication reservoir built in. Smaller radial bearing space with increased load capacity permits more compact and less expensive housing facilities. All add up to improved anti-friction performance. Use with or without inner race in shaft sizes from ⅜" to 9¼". Write for data now!

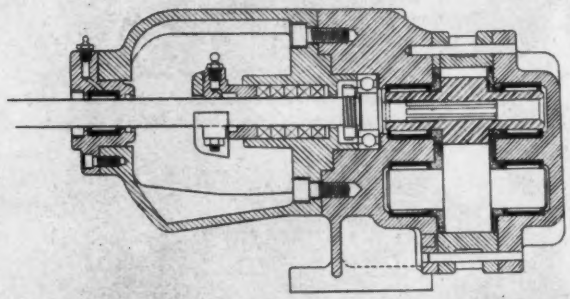




In typical capstan application MULTIROL SE Series maximum capacity bearings fit the small space under the cable drum, yet accept large diameter shaft necessary to carry heavy overhung load.



Use MULTIROL SE Series bearings on sheaves for maximum shaft diameter of pin and minimum housing OD . . . increases load capacity. Lubrication with Alemite fittings need less care than oil bath with plain bearings.



On a rotary gear pump, the heavier load capacity and comparatively small OD of SE Series MULTIROL Bearings permits use of larger shaft that resists deflection. Precision anti-friction requires less power imput.

Interested in SE Series MULTIROL bearing advantages? Write today for your copy of Bulletin SE-48. McGill Manufacturing Co., Inc. 201 N. Campbell St., Valparaiso, Indiana

McGILL
TRADE MARK
precision bearings

POST

P.T.M. 173

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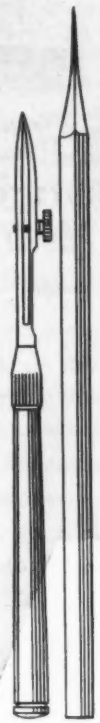
MADE TO MEET YOUR REQUIREMENTS

Exactly!



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FOR EVERY PLAN YOU MAKE — — — THERE'S A PAPER BY POST

UNITS BUILT FOR HEAVY PRODUCTION...

USE **BARCO** JOINTS TO KEEP PRESSURE LINES *FLEXIBLE...*

Barco Flexible Joints provide for expansion and contraction, keep pipes aligned, protect fluid-conveying systems throughout transportation and industry against interruptions or breakdowns. For over 40 years Barco has provided responsive, compensating movement through every angle. Today, there is a Barco Flexible Joint for every need. For more details, write Barco Manufacturing Company, 1827 Winnemac Avenue, Chicago 40, Illinois. In Canada: The Holden Co., Ltd., Montreal, Canada.

BARCO JOINTS ON A MUD PUMP FOR THE OIL FIELDS

This is one of the many applications using Barco Flexible Joints where a flexible conveyor is required for oil, steam, air, gasoline, tar, water and other fluids. You will find Barco Joints in oil refineries, steel mills, shipyards, working on a wide variety of machines.

BARCO *FLEXIBLE JOINTS*

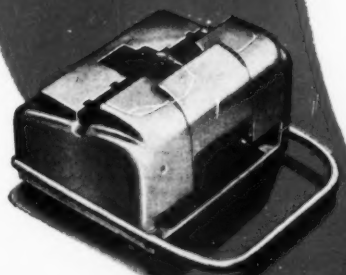
Not just a swivel joint ...but a combination of a swivel and ball joint with rotary motion and responsive movement through every angle.

FREE ENTERPRISE—THE CORNERSTONE OF AMERICAN PROSPERITY

"MOVE IN EVERY DIRECTION"

TAKE THE DEAD WEIGHT OUT OF YOUR PRODUCT WITH

"DOLER-MAG"* MAGNESIUM



YOUR PRODUCT
could be a design success story like these!

SCINTILLA DISTRIBUTOR HOUSING FOR AIRCRAFT ENGINES

Lightness plus our ability to cast the many holes determined the use of "DOLER-MAG" die casting in this operation.

8½" Diameter x 3⅛" High. Weighs—1.85 lbs.

UNDERWOOD ELECTRIC TYPEWRITER
(Assembled)

The number of magnesium die castings used in this unit reduce weight and provide necessary stiffness and rigidity. Damping capacity effectively reduces vibration and operational noise.

Six parts—Total Weight 4.573 lbs.
Equivalent steel parts weigh 4 times as much.

*Reg. U.S. Pat. Off.

"DOLER-MAG" *magnesium die castings give you these advantages:*

Lightest weight alloy die cast • Supply inexhaustible • Non strategic • Machining at higher speeds • Machining with greater economy • Excellent dimensional stability • Excellent noise damping quality • Excellent paint or coat finish • Non sparking • Non toxic • Non magnetic

SEND FOR MORE INFORMATION TODAY.

Doehler-Jarvis Corporation
386 Fourth Avenue, Dept. S-5
New York 16, N. Y.

Please send me your special pamphlet on "Doler-Mag," plus other technical pamphlets on various die casting applications.

Name.....
Company.....
Street.....
City.....*State*.....

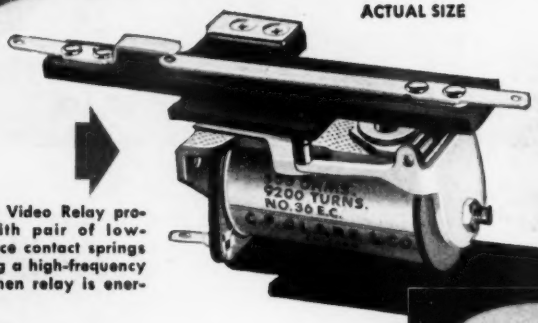
DOEHLER-JARVIS CORPORATION

The World's Largest Producer and Finisher of Die Castings

Executive Office
386 FOURTH AVENUE
NEW YORK 16, N. Y.

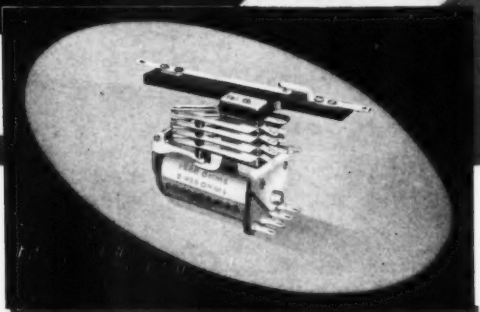
How Big does a Video Relay have to be?

ACTUAL SIZE



Type "J" Video Relay provided with pair of low-capacitance contact springs for closing a high-frequency circuit when relay is energized.

This Type "J" Video Relay shows how a number of auxiliary contact springs may be added for switching circuits which do not carry high-frequency currents.



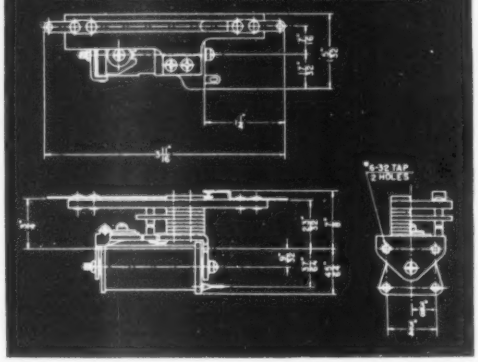
RCA Engineers posed this question to CLARE when available relays for their purpose proved too large, too cumbersome.

The close cooperation between engineers of the two companies which resulted has produced the CLARE Type "J" Video Relay, which meets every requirement for switching these high-frequency currents... and occupies but 7 cubic inches.

Success of this cooperation between RCA and CLARE engineers in developing a superior small-size, low-capacitance relay is not only important to this, the world's largest manufacturer of radio and television equipment, but it is of vital interest to every television engineer whose designs are often frustrated by the 17 cubic inches that other typical video relays require.

Clare sales engineers are located in principal cities. They will be glad to give you full information on this new video relay. Their counsel and advice may help you solve other relay problems. More and more, industrial designers bring their problems to Clare, whose long experience in meeting and solving them can save you many hours of tedious and costly experiment. Call your nearest CLARE sales engineer, or write to: C. P. Clare & Co., 4719 West Sunnyside Ave., Chicago 30, Illinois.

Dimensions of CLARE Video Relay



Capacitance of CLARE Video Relay

Tests show that this new CLARE relay with a contact gap of 0.025" has the following capacitances:

Interspring Capacitance, Contact Open

0.5 mmf. at 3 megacycles
0.5 mmf. at 10 megacycles
0.55 mmf. at 20 megacycles

Spring-to-Frame Capacitance, Contact Closed

1.4 mmf. at 3 megacycles
1.45 mmf. at 10 megacycles
1.8 mmf. at 20 megacycles

Write for Clare BULLETIN 106

CLARE RELAYS

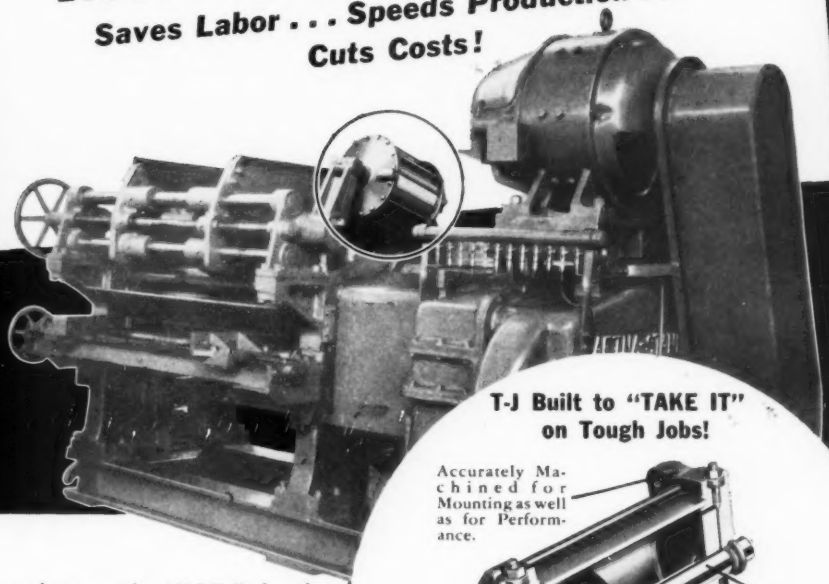
First in the Industrial Field

Job File No. 1001

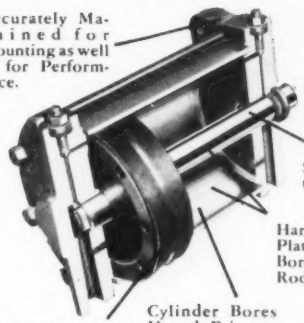
T-J CYLINDER

EJECTS 6-TON STEEL COILS

Saves Labor . . . Speeds Production . . . Cuts Costs!



T-J Built to "TAKE IT" on Tough Jobs!


Accurately Machined for Mounting as well as for Performance.
Shouldered Piston Rods.
Hard Chromium Plated Cylinder Bores and Piston Rods.
Cylinder Bores Honed Prior to Hard Chromium Plating.
Self Sealing Packings throughout.

Here's another example of T-J Cylinders doing a job of power movement for industry . . . *efficiently . . . accurately . . . automatically.* This machine is an Aetna Standard Roll Type Coiler, which employs a T-J Air Cylinder to eject steel coils weighing up to 12,000 lbs.! As the strip of steel is completely coiled, kick-out fingers operated by the cylinder raise the coil and push it forward where it rolls on to conveyor.

T-J Air and Hydraulic Cylinders are built for 1001 tough jobs like this, where pushing, pulling or lifting is needed . . . 100 lb. or 50,000 lb. Available in many standard sizes and styles . . . both cushioned and non-cushioned types. Backed by 32 years' experience . . . built for long-life dependability. Write for latest catalogs. The Tomkins-Johnson Co., Jackson, Michigan.

FOR POWER MOVEMENT IN ANY DIRECTION

100 LB. or 50,000 LB.

T-J 32 YEARS EXPERIENCE

TOMKINS-JOHNSON

RIVITORS...AIR AND HYDRAULIC CYLINDERS...CUTTERS...CLINCHORS

in "Suspense!" . . . CBS Radio Network
days . . . CBS Television Tuesdays.

DESIGN *for better living!*

• New beauty, convenience, economy has been made possible through the use of plastics and metal and plastic combinations. The modern automobile has demonstrated this great potential. And the broad scope of the varied applications is being repeated again and again throughout industry.

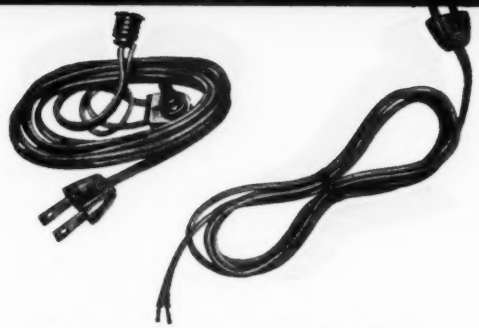
Here under one roof at Auto-Lite's great Bay Manufacturing Division in Bay City are the technical skills and production capacity for a new art rendered in plastics. The artistic skill of Auto-Lite's Art and Style Division is available on matters of design and development.

THE ELECTRIC AUTO-LITE COMPANY
Bay Manufacturing Division
723 New Center Bldg., Detroit 2, Michigan • Bay City, Michigan

Auto-Lite
plastics and metals

AUTO-LITE MEANS PRECISION MANUFACTURING

Wiring Components FOR PRODUCT DESIGN



CAN YOU USE THIS COST-CUTTING SERVICE?

Here's a service designed to cut your assembly time and increase your selling story. It's the General Electric Flamenol* cord set service—a service designed to cut product assembly time to an absolute minimum.

Here's what we did for one manufacturer: In addition to the standard molded-on plug, and cord with stripped and twisted ends, we included both a switch and a socket. (This time-saving assembly is shown at left, above.) If you produce your product in volume, you'll be interested in this General Electric service. But . . .

If you have no assembly problems, you can order standard General Electric Flamenol cord sets in ready-cut lengths of 6, 8, and 11 feet. They make work easy because ends are stripped and twisted for easy connection. And . . .

They are visible evidence of high quality on any product. That's why General Electric Flamenol cord sets are boosting sales of cord-equipped products all over the country.

Flamenol cord sets have a strong, molded-on plug that keeps the double-strength prongs straight and true. The smooth, thermoplastic insulation cleans in a jiffy with a quick wipe and won't fray, kink or pull loose from the plug.

We've made millions of them for use on clocks, lamps, fans, radios and a host of other light-duty appliances, so why not take advantage of our experience? Just tell us what you want, and we'll tell you what we can do. Check box A below.

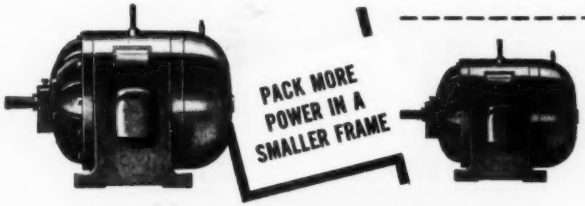
CORDS BUILT TO TAKE TOUGH TREATMENT

That's a built-in feature of every General Electric portable cord—ability to take the same tough treatment you've designed into your product.

For example, Type ST Flamenol heavy-duty portable cords are designed to give long term, dependable service under severe operating conditions. They are flexible, light in weight, easy to handle and mechanically tough and strong. The thermoplastic jacket is resistant to water, oils, alkalies, sunlight and acids. Type ST cords are recommended for use on portable tools in industrial plants, mines, garages, packing houses, and similar tough-duty locations.

Perhaps your product does not require a cord built to meet such heavy duty requirements. But whatever your requirement—from light-duty appliance to heaviest tool—there is a General Electric portable cord to supply power to it.

Do you have a power cord problem—would you like to know more about General Electric portable cords? Just check C in the coupon.



Today's emphasis on greater power output from smaller motor frames makes magnet wire selection more important than ever before. That's why it's a wise designer who investigates the many features of General Electric Deltabeston* magnet wire before writing his specs.

Deltabeston magnet wire can take overload temperatures as high as 200 C. The purified-asbestos insulation is firmly bonded to the conductor with a special heat-resisting adhesive and by an exclusive process. This tough, flexible insulation, plus the extreme softness of the copper, permits the use of Deltabeston for the most intricate winding applications.

But get the whole story. We've prepared it in an interesting booklet that includes a handy table to simplify selection. If you'd like a free copy, just check B in the coupon below.

Trade-mark Reg. U. S. Pat. Off.

General Electric Company (Section L3-567)
Construction Materials Department
Bridgeport 2, Connecticut

Please send me, free, the items checked below:

- A ☐ General Electric Flamenol cord set service
- B ☐ Deltabeston Magnet Wire Booklet
- C ☐ Information on General Electric portable cords
- D ☐ Information on the subject attached

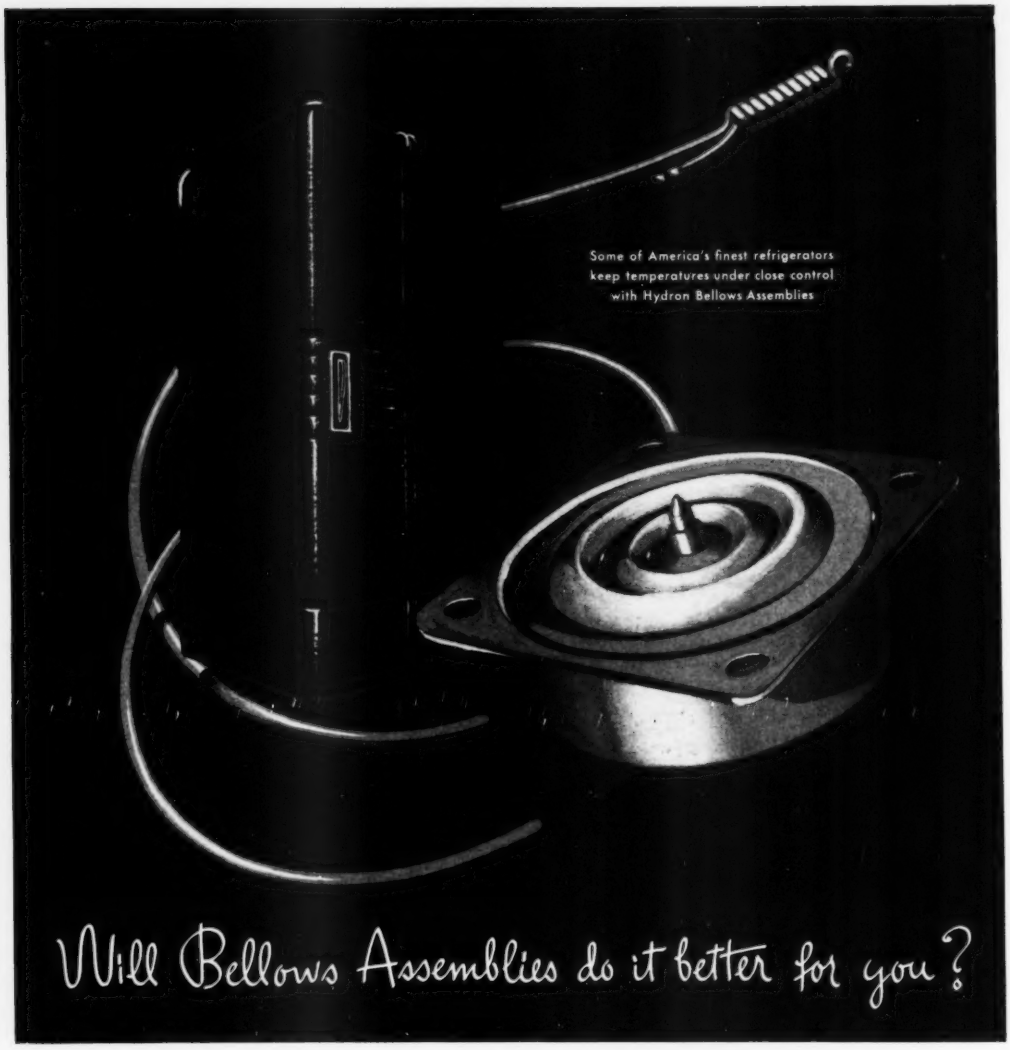
Name _____

Company _____ Title _____

Street _____

City _____ Zone _____ State _____

GENERAL ELECTRIC


Some of America's finest refrigerators keep temperatures under close control with Hydron Bellows Assemblies
Will Bellows Assemblies do it better for you?

Many other firms looking for better ways to control temperature or pressure, to seal shafts or valves against leakage, or to transmit motion, have turned to bellows assemblies. Investigation before your designs are too far advanced may pay you, too. Let our engineering department make a confidential analysis of your sketches and specifications and make a recommendation. No obligation, of course.

CLIFFORD MANUFACTURING COMPANY, 122 GROVE ST., WALTHAM 54, MASS. *Division of Standard-Thomson Corporation.* Offices in New York, Detroit, Chicago, Los Angeles.

HYDRON

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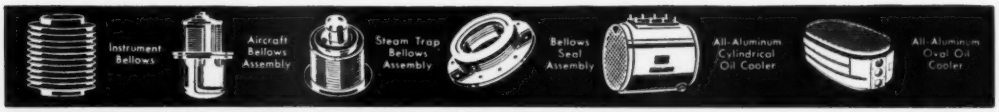
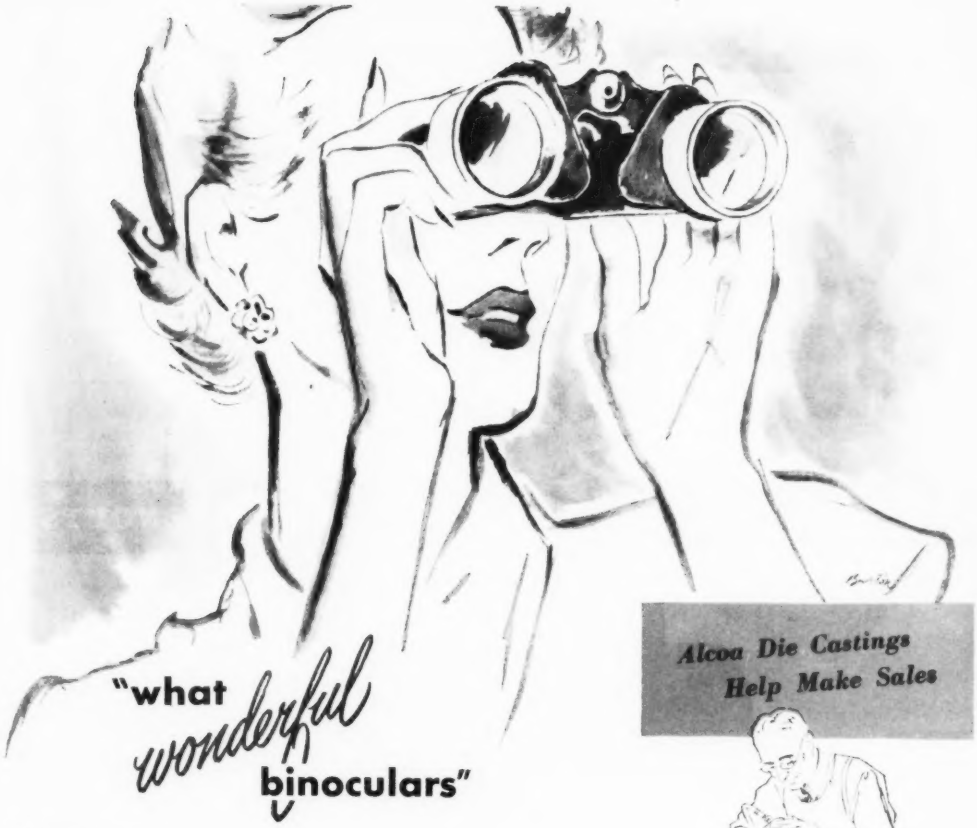
Fredtex Wright

HYDRAULICALLY-FORMED BELLOWS AND BELLOWS ASSEMBLIES

ALL-ALUMINUM OIL COOLERS FOR AIRCRAFT ENGINES





Alcoa Die Castings Help Make Sales

She knows—

They are so light, so strong, priced right. The salesman assured her, the manufacturer guaranteed, the glasses would take abuse. She bought them.

Thousands wanted and bought aluminum binoculars. Now they are the accepted standard. Alcoa Aluminum Die Castings helped loosen purse strings for sales-wise manufacturers . . . gave the optical industry a lift.

There is added appeal for your product as an Alcoa Die Casting. Start planning. Call on Alcoa's 61 years of light-metal experience and 34 years of die-casting know-how for the help you need. Ask for a copy of "Designing for Alcoa Die Castings". Your Alcoa sales office will supply you, or write ALUMINUM COMPANY OF AMERICA, 611 Gulf Building, Pittsburgh 19, Pa.

She doesn't know—

Beyond the ability of the Alcoa organization lie important advantages of Alcoa Die Castings themselves. They won't creep under sustained loads, show little growth even at elevated temperatures. They are excellent conductors of heat and electricity. Add these advantages to a bonus of light weight and a competitive price structure.

ALCOA ALUMINUM Die Castings merit your FIRST consideration

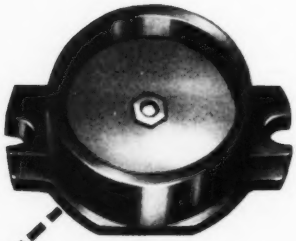
ALCOA FIRST IN ALUMINUM

ALCOA ALUMINUM

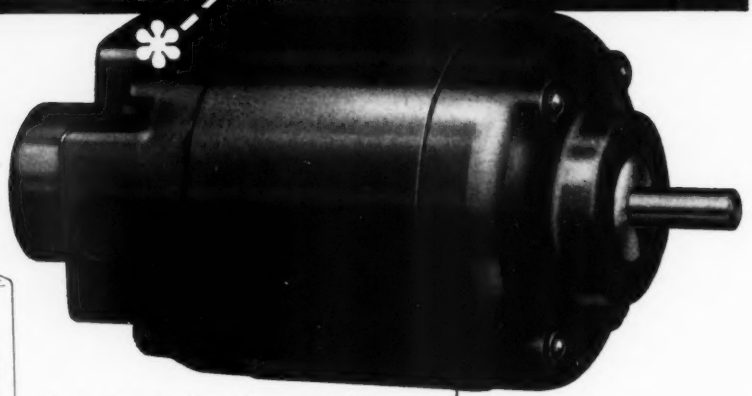
INGOT • SHEET & PLATE • SHAPES, ROLLED & EXTRUDED • WIRE • ROD • BAR • TUBING • PIPE • SAND, DIE & PERMANENT MOLD CASTINGS • FORGINGS • IMPACT EXTRUSIONS
ELECTRICAL CONDUCTORS • SCREW MACHINE PRODUCTS • FABRICATED PRODUCTS • FASTENERS • FOIL • ALUMINUM PIGMENTS • MAGNESIUM PRODUCTS

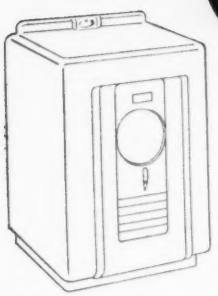
IN WASHING MACHINE MOTORS

KLIXON PROTECTORS



PROVIDE LONG LIFE BY PREVENTING BURNOUTS





In a recent National Consumer Poll*, one of the most desired features wanted by users of washing machines was motors with built-in motor protection.

As a manufacturer of washing machines, you can provide this safety feature by simply specifying that your motor manufacturer supplies you with motors that have built-in Klixon Protectors. The additional cost is low yet you give users motor overheat protection that keeps motors working for the full life of the washing machine.

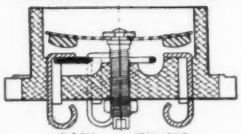
Remember, too, regardless of the product you make . . . washing machines, circulating pumps, oil burners, etc. . . . you can build product reputation and good will by always using motors that have Klixon Protectors.

*Name on request

KLIXON
TRADE MARK REG. U. S. PAT. OFF.

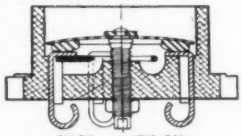
SPENCER THERMOSTAT
Division Metals & Controls Corp.
909 Forest Street, Attleboro, Mass.

HERE'S HOW KLIXON PROTECTORS WORK!



CLICK . . . IT'S OFF!

When temperature within the equipment reaches danger point, KLIXON Protector snaps the power "off" preventing burnouts.



CLICK . . . IT'S ON!

When the equipment cools to safety, the Klixon Protector snaps the power "on" automatically if the automatic reset is specified . . . or when the reset button is pushed when manual type is specified.

NATIONAL OIL SEAL LOGBOOK

USE OF DUAL-WIPE "SYNTECH" OIL SEALS

Modern precision machines operate at speeds and temperatures once thought impossible. But the gears and bearings of these "lickety-split" mechanisms still need oil seals to guard against loss of lubricants or damage from external abrasives. Doing this job effectively and safely often requires oil seals as new and specialized as the machines themselves.

Typical of new oil seals developed to meet this challenge are the National 10,000S (Fig. 1) and National 30,000S series (Fig. 2). The 10,000S series is designed for moderate external dust conditions, speeds to 3600 FPM, and temperatures not over 300°F. The 30,000S series is for heavier abrasive conditions, speeds to 2500 FPM, and temperatures not over 300°F.

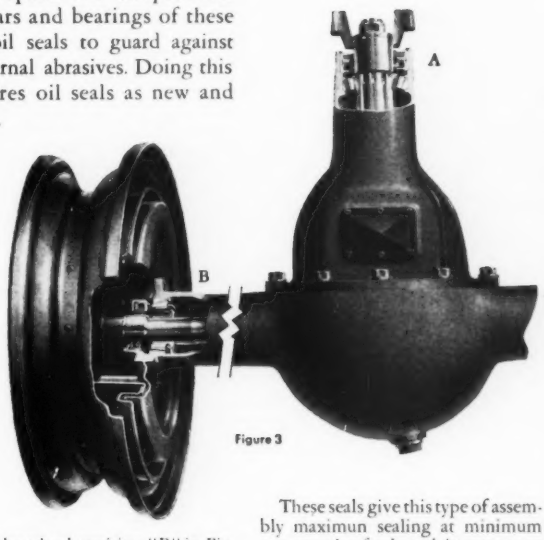


Figure 3

Both types of seals are used on high speed rear axle and pinion assemblies of modern automobiles and light trucks; on engine crankshafts, power fans, large electric motors and gear boxes of all kinds.

At the pinion "A" in Fig. 3, a National 10,000S seal is used. Its felt outer auxiliary member guards against light dust at the pinion, and can run "dry" at high speeds without injury. The spring-loaded main member, of compounded synthetic rubber, has minimum torque yet retains a pressure head of lubricant with zero leakage.

At the wheel position, "B" in Fig. 3, a National 30,000S seal is used. Here speeds do not exceed 800 R.P.M., but absolute "zero leakage" is desired and external abrasives are a constant hazard. This seal employs an accurately spring-loaded synthetic-rubber sealing member to retain bearing lubricant. The outer seal is a rugged leather flange which effectively excludes concentrated dust and dirt.

These seals give this type of assembly maximun sealing at minimum torque—the final goal in every use of the dual seal. Other seal types are available which will solve many specific problems. However, when one or more conditions are unusually extreme, a special seal design may be required.

For more information, contact the National Oil Seal Engineer nearest you or write direct.

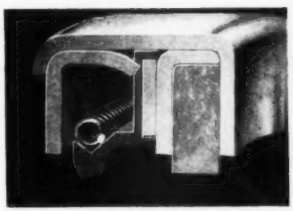


Figure 1

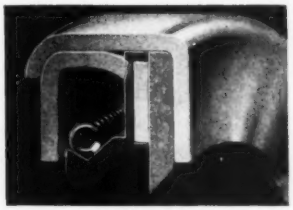


Figure 2

NATIONAL
OIL AND FLUID SEALS

NATIONAL MOTOR BEARING CO., INC.

General Offices: Redwood City, California
Plants: Redwood City and Los Angeles, California; Van Wert, Ohio

CALL IN A NATIONAL ENGINEER FOR RECOMMENDATIONS

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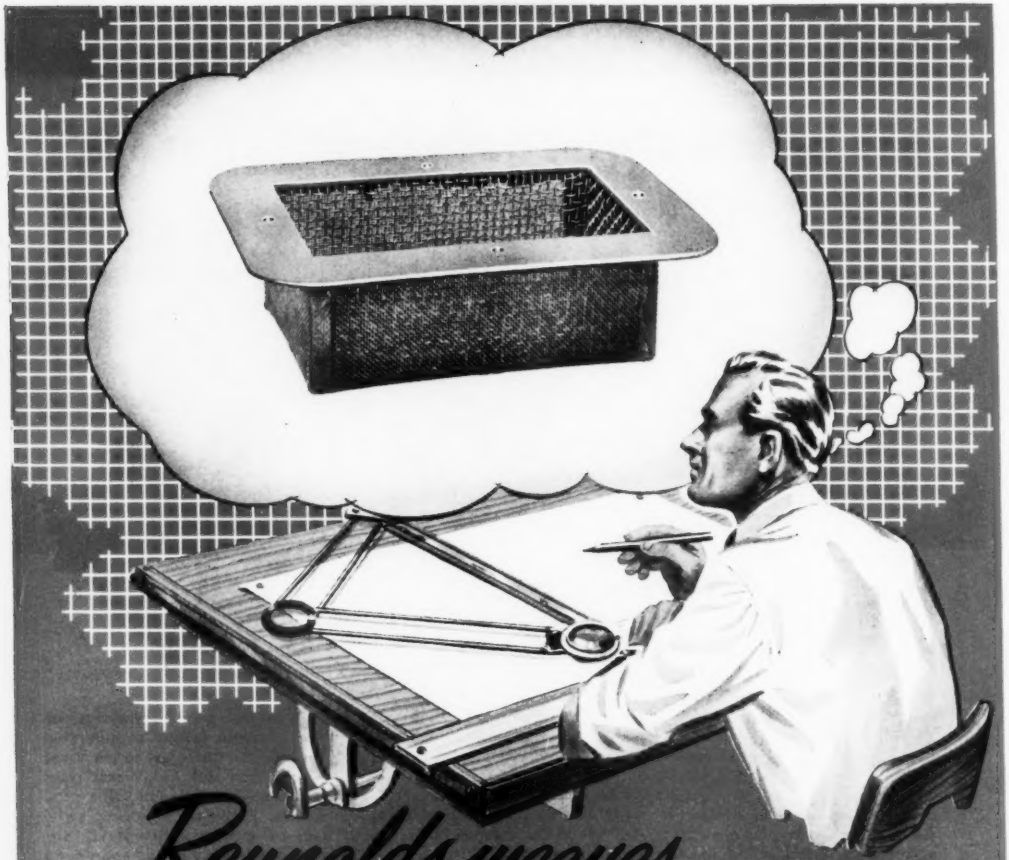
CHICAGO: Room 2014 Field Building, Central 6-8663.
CLEVELAND: 210 Heights Rockefeller Bldg., Yellowstone 2720.
DALLAS: 301½ Highland Park Village, Justin 8-8453.
DETROIT: Room 1026 Fisher Building, Trinity 1-6363.
HOUSTON: 6731 Harrisburg Boulevard, Wayside 3-1246.
LOS ANGELES: 2244 East 37th Street, Kimball 6384.
MILWAUKEE: 647 West Virginia St., Marquette 8-8986.
NEW YORK CITY: 122 East 42nd Street, Lexington 2-8260.
PHILADELPHIA: 401 North Broad Street, Bell-Walnut 2-6997.
REDWOOD CITY, CALIF.: Broadway and National, Emerson 6-3861.
WEST SPRINGFIELD, MASS.: 1025 Elm Street, Springfield 2-1881.
EAST SYRACUSE, N. Y.: 226 Roby Avenue, East Syracuse 366.
WICHITA: 340 North St. Francis Ave., Wichita 2-6971.

Reprints from this or other Logbook pages are available for your files. Request them from our Redwood City, California, office



Reynolds weaves

WIRE CLOTH EXACTLY TO YOUR SPECIFICATIONS

• Yes, your product *is* different. The wire cloth you put into your product must meet its special needs. You want cloth that is different from "standard." Then write your own specifications—Reynolds will weave it accordingly. Specify the metal or alloy, as well as the diameter of the wire—temper, workability and flexibility will be *right!* Weave and mesh of the cloth, and finish, too—all exactly as ordered. Reynolds knows how—from 53 years' experience. If you want your industrial wire cloth "tailor made," send your specifications to Reynolds engineers, metallurgists and weaving experts . . . an inquiry neither costs nor obligates you.

Reynolds
Industrial
WIRE
CLOTH

REYNOLDS WIRE CO., DIXON, ILLINOIS

YOU CAN BE **SURE**.. IF IT'S

Westinghouse

—and NOW...

Needs No Lubrication

Now . . . for the first time . . . you can install electric motors, or motor-driven machines . . . and forget motor lubrication.

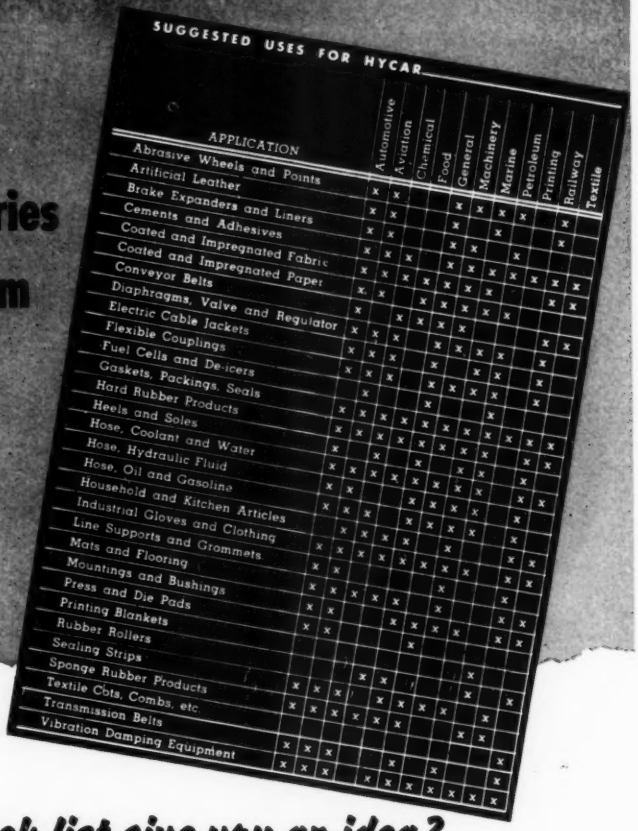
Westinghouse Life-Line . . . industry's amazing, new, all-steel motor . . . now completely eliminates need for lubrication. Life-Line motors are equipped with sealed bearings, pre-lubricated with a more-than-ample supply of specially treated lubricant. Correct lubrication is assured . . . machine outages are reduced . . . motor-drive problems are simplified, since motors can be located without need for constant accessibility.

Added to Life-Line's plate-steel protection, improved windings and more compact size, *pre-lubrication* is one more important reason for starting to convert, today, to Life-Line power. Standard ratings available from stock—others on short delivery. Ask your Westinghouse representative for prices and delivery on your requirements, or write Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pa.

J-21527-A

Westinghouse *Life-Line* Motors

11 important industries that benefit from HYCAR



SUGGESTED USES FOR HYCAR

APPLICATION	Automotive	Aviation	Chemical	Food	General	Machinery	Marine	Petroleum	Printing	Railway	Textile
Abrasive Wheels and Points	x	x			x	x	x	x		x	
Artificial Leather	x	x			x		x			x	
Brake Expanders and Liners	x	x			x	x	x	x		x	
Cements and Adhesives	x	x	x		x	x	x	x	x	x	x
Coated and Impregnated Fabric	x	x	x	x	x	x	x	x	x	x	x
Coated and Impregnated Paper	x	x			x	x	x	x		x	x
Conveyor Belts	x			x	x	x	x				
Diaphragms, Valve and Regulator	x	x	x	x	x					x	x
Electric Cable Jackets	x	x	x		x	x	x	x		x	x
Flexible Couplings	x	x	x		x	x	x	x		x	
Fuel Cells and De-icers	x	x	x		x		x	x		x	
Gaskets, Packings, Seals	x			x	x	x	x			x	
Hard Rubber Products	x	x	x	x	x	x	x	x	x	x	x
Heels and Soles	x	x	x	x	x	x	x	x	x	x	x
Hose, Coolant and Water	x		x		x	x	x	x		x	x
Hose, Hydraulic Fluid	x	x	x	x	x	x	x	x		x	x
Hose, Oil and Gasoline	x	x			x	x	x	x		x	
Household and Kitchen Articles	x	x	x		x	x	x	x		x	
Industrial Gloves and Clothing	x	x	x	x	x	x	x	x		x	
Line Supports and Grommets	x	x	x	x	x	x	x	x		x	
Mats and Flooring	x	x			x					x	
Mountings and Bushings	x	x	x	x	x	x	x	x		x	
Press and Die Pads	x	x			x					x	
Printing Blankets	x	x			x	x	x	x		x	
Rubber Rollers	x	x			x					x	
Sealing Strips					x						
Sponge Rubber Products	x	x	x		x	x				x	
Textile Cots, Combs, etc.	x	x	x	x	x	x	x	x		x	
Transmission Belts	x	x	x	x	x	x					
Vibration Damping Equipment	x	x	x		x					x	

Does this quick check list give you an idea?

THAT chart lists 30 groups of items that can be made from Hycar American rubbers, and shows 11 broad industrial classifications where these Hycar parts can be used advantageously. The chart is taken from the up-to-date Hycar booklet, "Everywhere in Industry," which describes Hycar's characteristics with full technical data. A FREE copy is yours for the asking.

But at best the list is an incomplete one that can only suggest applications for Hycar in your own business. Hycar's usefulness is so wide and its versatility so great that scores and hundreds of important applications have not yet even been thought of!

That's why we suggest that you carefully examine the list of Hycar's inherent properties shown in the box at the right. Keep in mind the requirements of *your* rubber parts. And remember that it's possible to select exactly the right *combination* of properties to meet your established service conditions. Then—*ask your supplier for parts made from Hycar* for test in your own applications—difficult or routine.

You'll find that the use of Hycar parts will save you money—that it's wise to use Hycar for long-time dependable performance. For more information, please write Dept. HJ-5, B. F. Goodrich Chemical Company, Rose Building, Cleveland 15, Ohio.

Hycar
Reg. U.S. Pat. Off.
American Rubber

CHECK THESE SUPERIOR FEATURES OF HYCAR

1. **EXTREME OIL RESISTANCE**—insuring dimensional stability of parts.
2. **HIGH TEMPERATURE RESISTANCE**—up to 250° F. dry heat; up to 300° F. hot oil.
3. **ABRASION RESISTANCE**—50% greater than natural rubber.
4. **MINIMUM COLD FLOW**—even at elevated temperatures.
5. **LOW TEMPERATURE FLEXIBILITY**—down to −65° F.
6. **LIGHT WEIGHT**—15% to 25% lighter than many other synthetic rubbers.
7. **AGE RESISTANCE**—exceptionally resistant to checking or cracking from oxidation.
8. **HARDNESS RANGE**—compounds can be varied from extremely soft to bone hard.
9. **NON-ADHERENT TO METAL**—compounds will not adhere to metals even after prolonged contact under pressure. (Metal adhesions can be readily obtained when desired.)

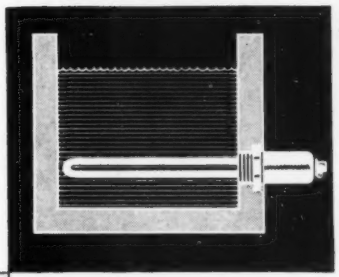
B. F. Goodrich Chemical Company
A DIVISION OF THE B. F. GOODRICH COMPANY

GEON polyvinyl materials • HYCAR American rubber • GOOD-RITE chemicals and plasticizers

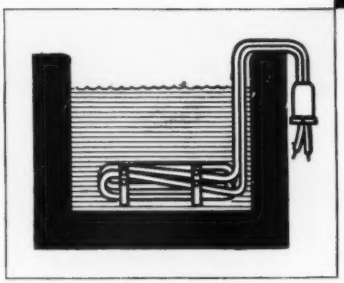
heating liquids?

For greater heating efficiency with minimum heat losses...

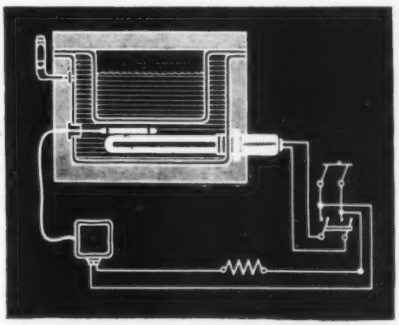
Specify General Electric Calrod* HEATERS



◀ **"SCREW-IN" TYPE** Calrod immersion heaters are real, compact space-savers. Mounted through the side or bottom of the liquid containers, they give you *direct placement* of the heat source . . . right into the liquid. Available in many sheath materials, you can get these Calrod heaters in ratings from .6 to 10 kw or more.



◀ **"OVER-THE-SIDE" TYPE** Calrod immersion heaters are readily portable, easily removed for cleaning, and are particularly suitable for use with rubber or lead-lined tanks; tanks of wood, slate, and other materials not readily adaptable to heaters with threaded headers. These heaters come in a wide variety of sheath materials and formations in ratings from 2 to 6 kw or more.



"JACKETED" CONSTRUCTION is used when ▶ liquids do not permit direct immersion of the heaters. Carbonizing of highly viscous materials and "boiling-out" of solvents in certain compounds is prevented by temperature control equipment. Steam-jackets are used where higher temperatures and quicker transfer of heat is desired.

*Reg. U.S. Pat. Off.

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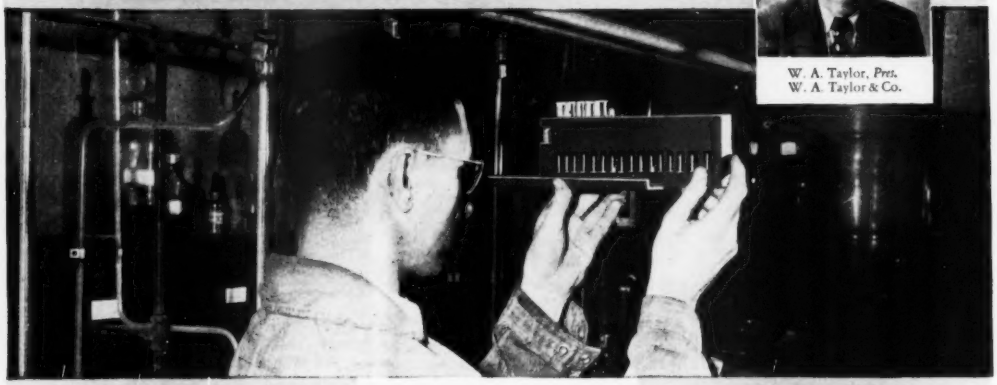
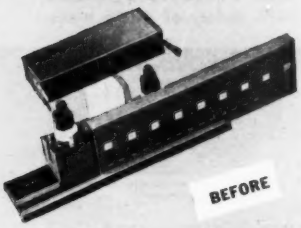
It pays to use your custom molder's know-how

says the maker of Taylor "Comparators"

No. 5 in a series on Plastics Skill at Work . . .

W. A. Taylor, *Pres.*
W. A. Taylor & Co.





BEFORE

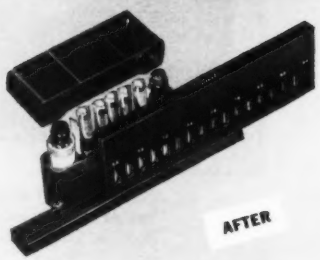
PROJECT: Five-part Slide, Body and Cover for pH and Chlorine Control Device

CUSTOMER: W. A. Taylor & Co., Baltimore, Maryland

MOLDER: Plastics Division, Colt's Manufacturing Co.

MATERIAL: Compression Molded Durez Phenolic Plastic

IMPROVEMENTS: Reduced weight, faster assembly, improved appearance and wearing qualities, better talking points for salesmen



AFTER

● Like other products of every conceivable kind, the *Comparators* made by W. A. Taylor & Co. were perfect . . . *until someone saw how to improve them.*

The "someone" in this case, which is so typical it might be duplicated in your own operation, was a custom molder working with Taylor planning executives.

These comparators were selling so fast to laboratories in 35 major industries that the maker grew concerned about production. The molder, Plastics Division of Colt's Mfg. Co., requested permission to redesign for improved speed of output, ease of use, and appearance. Experimentation with models evolved the present design, an all-round better product molded of Durez phenolic plastics.

Right away, the restyling in Durez reduced the weight by a third, lightening work for laboratory men everywhere. Weight is also balanced better in the Durez pieces, assembly in production is faster, and window cuts are more accurate. The plastic parts, being impervious to mild acids and alkalis, and to laboratory fumes, keep their lustrous look of newness indefinitely.

Durez field men, with an experience-backlog covering the entire progress of plastics, will gladly team up with you and your molders. Call on them freely.

Durez Plastics & Chemicals, Inc., 155 Walck Rd., N. Tonawanda, N. Y.

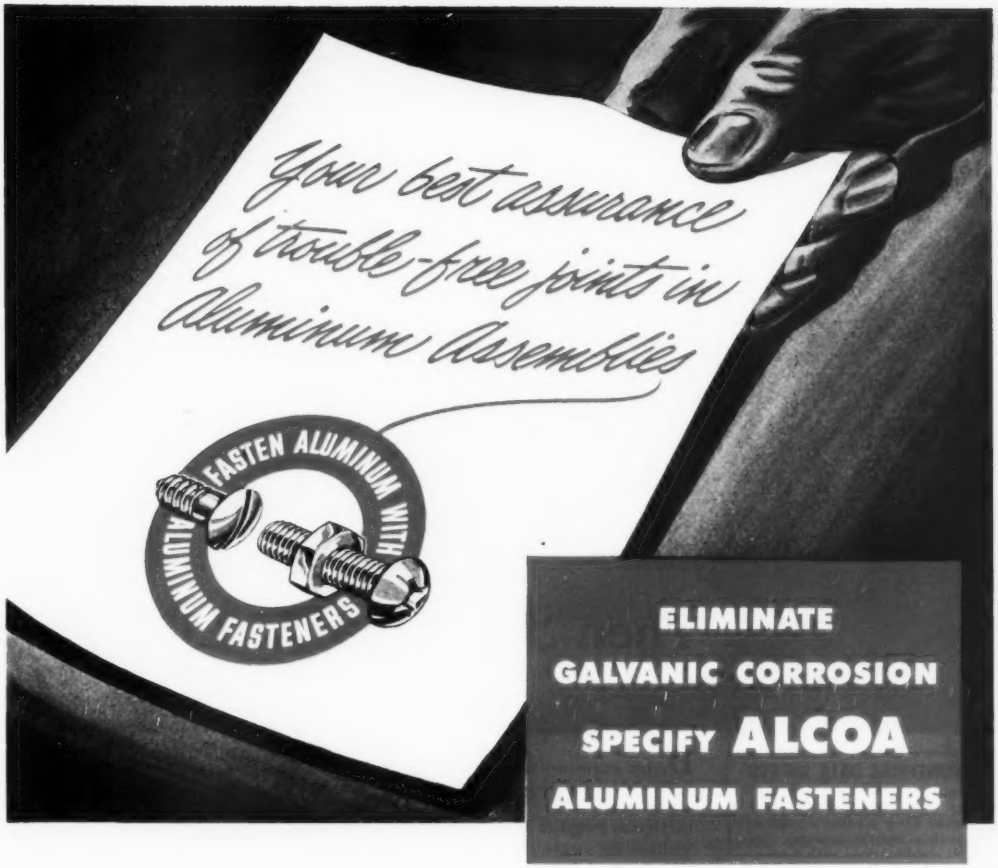
A new hit with plastics users everywhere is the handy "Durez Check-Chart." Write for yours. Durez Plastics & Chemicals, Inc., 155 Walck Rd., N. Tonawanda, N. Y.

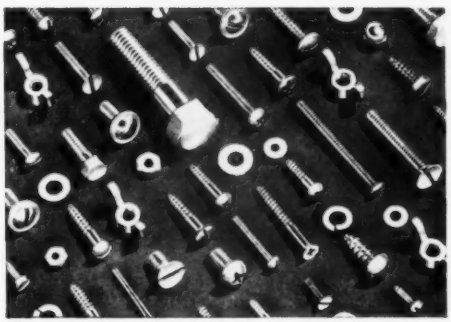
DUREZ

PHENOLIC RESINS

- MOLDING COMPOUNDS
- INDUSTRIAL RESINS
- PROTECTIVE COATING RESINS

PHENOLIC PLASTICS **THAT FIT THE JOB**





You can prevent the galvanic corrosion that can result when dissimilar metals are used to fasten aluminum assemblies: Fasten aluminum with Alcoa Aluminum Fasteners.

Alcoa Fasteners are available from stock with Phillips heads for fast, slip-free power driving, or slotted heads; in sheet metal, wood and machine screws; all popular sizes, standard threads. Nuts, bolts, washers, lock washers, solid or tubular rivets and cotter pins are also available.

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ALCOA *Aluminum* FASTENERS

ENGINEERING DATA SHEETS

Send for the Mallory Engineering Data Sheets on the RS series. They contain complete specifications for available circuit combinations with respective terminal locations, dimensional drawings — everything the engineer needs.

SPECIFICATION SHEETS

Specification sheets for all RS switches have also been prepared. These sheets are printed on thin paper to permit blueprinting. The sectional drawings indicate standard and optional dimensions—make it easy for you to order production samples built to your requirements.

There is a Mallory switch to fit your design—write for further details.

Design engineers who specify Mallory RS switches *know* they are getting the best that substantial construction and precision manufacturing can produce. They know that Mallory RS switches protect their good name because they provide maximum long-life and efficient dependable service.

Mallory RS switches are available with cam and ball type index assembly, or with positive indexing hill-and-valley double roller type index assembly.

These are the features that make Mallory switches famous for dependability and quality. All are advantages of extreme importance in television and high frequency applications where stability is essential.

- Insulation of high-grade, low-loss laminated phenolic.
- Terminals and contacts of special Mallory spring alloy, heavily silver-plated to insure long life at low contact resistance.
- Terminals held securely by exclusive Mallory two-point fastening—heavy staples prevent loosening or twisting.
- Double wiping action on contacts with an inherent flexing feature—insures good electrical contact with the rotor shoes throughout rotation.
- Six rotor supports on the stator—insure accurate alignment.
- Brass rotor shoes, heavily silver-plated—insure low contact resistance.
- All shoes held flat and securely to phenolic rotor by rivets—prevents stubbing—insures smooth rotation—*minimum of noise in critical circuits.*

Precision Electronic Parts—Switches, Controls, Resistors

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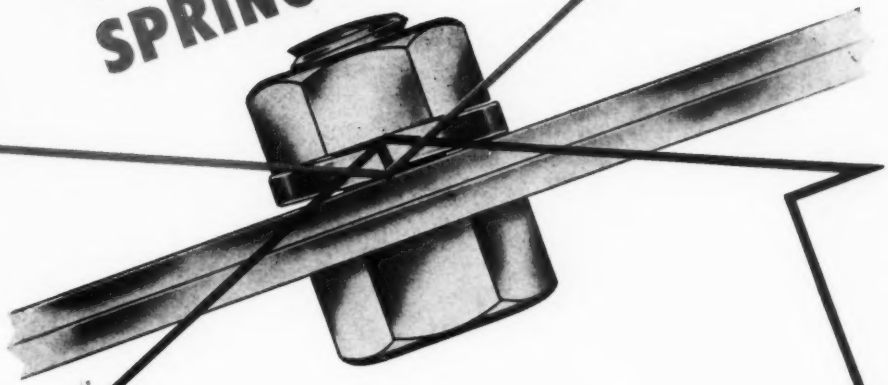
MALLORY

P. R. MALLORY & CO., Inc., INDIANAPOLIS 6, INDIANA

SERVING INDUSTRY WITH

Capacitors Rectifiers
Contacts Switches
Controls Vibrators
Power Supplies
Resistance Welding Materials

CONCENTRATED SPRING POWER



to keep bolted assemblies under tension – and tighter longer

Reliance Spring Lock Washers offer a dependable method of keeping bolted assemblies tight.

Their helical coil spring design, when compressed, builds up a powerful mechanical reactive pressure between nut or bolt head and the bolted surface. By maintaining bolt tension, this reactive pressure keeps nut or bolt from turning where thread fits are not tight and also automatically compensates for looseness resulting from service wear. Reliance Spring Lock Washers are available with a reactive range adequate to meet every service need.

Reliance Spring Lock Washers also act as hardened thrust bearings, reduce surface resistance and permit greater tightening torque.

Extremely simple, they do not depend upon a design which might fail in service and can be used with any type of nut or under bolt heads — cannot damage bolt threads.

Reliance Spring Lock Washers are available in carbon, alloy or stainless steel, bronze, K-Monel or aluminum.

When product performance and safety depend on bolt tightness, play safe by using Reliance Spring Lock Washers.

EATON SPRINGTITES—Powerful Reliance Spring Lock Washers of proper type and size, permanently pre-assembled on bolts or screws—speed production, cut costs. Write for Eaton Springtite folder.

RELIANCE RINGS—provide strong, heat treated shoulders on shafts or in counter-bores, lock assemblies securely. On in a jiffy, off in a jiffy, they speed production, cut costs. Write for Reliance Ring folder.

RELIANCE *Spring* LOCK WASHERS

EATON

EATON MANUFACTURING COMPANY

RELIANCE DIVISION, MASSILLON, OHIO

Sales Offices: New York, Cleveland, Detroit, Chicago, St. Louis, San Francisco, Montreal

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for VEE-BELT PULLEYS AND SHEAVES

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PRODUCTS: SODIUM COOLED, POPPET, AND FREE VALVES • TAPPETS • HYDRAULIC VALVE LIFTERS • VALVE SEAT INSERTS • ROTOR PUMPS • MOTOR TRUCK AXLES • PERMANENT MOLD GRAY IRON CASTINGS • HEATER-DEFROSTER UNITS • SNAP RINGS • SPRINGTITES SPRING WASHERS • COLD DRAWN STEEL • STAMPINGS • LEAF AND COIL SPRINGS • DYNAMATIC DRIVES, BRAKES, DYNAMOMETERS

Franks Truck-Mounted Rotary Drilling Rig on Oshkosh Chassis (with dual front wheels and four-wheel drive) uses Vickers Hydraulic Power Steering for easy and SAFE STEERING.

WITH *Hydraulic*

POWER STEERING

With ordinary steering, front-wheel loading is sharply limited by what the driver can pull and by acceptable steering gear ratios. But with Vickers Hydraulic Power Steering, the driver doesn't have to pull . . . hydraulic power does the work. Front-wheel loading can be any amount the chassis can take. No matter how much it is, the steering is effortless and safe. The Vickers Hydraulic Booster puts no load on the steering gear. The steering force reaction is absorbed by the frame . . . so front-wheel loading does not affect the steering gear. Write for Bulletin 47-30a for the many other advantages of Vickers Hydraulic Power Steering. 3822

VICKERS HYDRAULIC POWER STEERING IS *Effortless, Positive, Shockless.*

Vickers Hydraulic Steering Booster with Integral Overload Relief Valve. Bulletin 47-30a.

Vickers Balanced Vane Type Pump is Engine Driven. Bulletins 36-12 and 49-52.

VICKERS Incorporated
DIVISION OF THE SPERRY CORPORATION
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Sure Cure for gas or liquid leaks

No. 304-N Sylphon Packless Valve comes in sizes from ½" to 2" for pressures up to 150 lbs. Also available in larger sizes is No. 1304 with flanged connections for liquid pressures up to 80 lbs. No. 304-NV is ideal for vacuum service.

SYLPHON packless valves

● Even tiniest leaks of valuable liquids or gases are *stopped*—with Fulton Sylphon Packless Valves. Installed on pipe lines carrying oil, gasoline, or other volatile liquids or vapors, these valves prevent waste—provide vacuum protection. They guard you and your equipment against costly losses, explosion, fire, and other damage.

The valve has a dual-ply, seamless Sylphon metal bellows instead of the customary packing—eliminating leakage that can seep past the stuffing box of an ordinary packed type valve. The bellows provides a positive seal—is metal-housed for protection against erosion. Available in many sizes and types with body made of brass, bronze, cast iron, cast steel, stainless steel or monel.

Widely used in chemical plants, oil refineries, power plants, aboard ships—or wherever steam, air, gases or liquids are handled. For complete information, please write for Bulletin JP-813.

FIRST WITH BELLOWS

Temperature Controls • Bellows Devices • Bellows Assemblies

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DIVISION

ROBERTSHAW-FULTON CONTROLS CO., KNOXVILLE 4, TENN.

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GEAR SPECIALIZES IN *Uniformity*

WHETHER you need *one* thousand or a *hundred* thousand . . you'll get a degree of UNIFORMITY in G.S. Small Gearing unapproached, we believe, in the history of the industry! Such extreme accuracy in the speedy *mass production* of Fractional Horsepower Gears comes from over 30 years of specialization. G.S. craftsmen, together with highly developed methods and machinery, possess the ability to economically produce *quantities* of Small Gears . . each one uniformly cut to meet the most exacting specifications. Here, then, is a really *dependable* source of supply for ALL of your Fractional Horsepower Gearing requirements. Year after year, more and more particular buyers are looking to us for the kind of service and cooperation they need. Let our Small Gearing Specialists also help you to get better gears at moderate cost. Suggestions, ideas, and cost estimates won't obligate you at all. Write or phone us today!

GEAR Specialties

Spurs • Spirals • Helicals • Bevels • Internals • Worm Gearing • Racks • Thread Grinding

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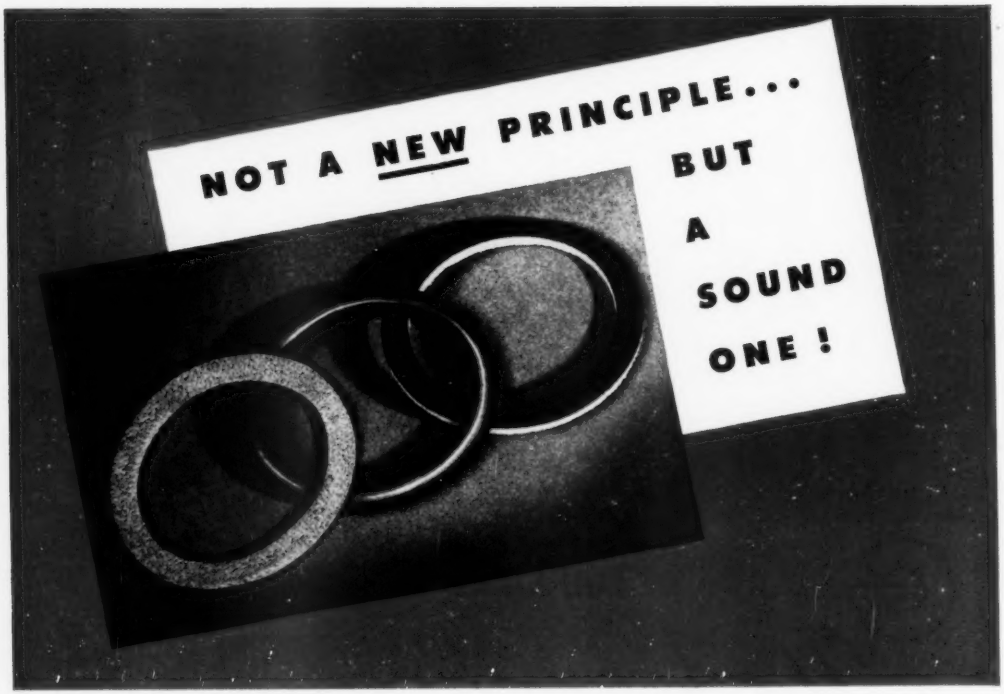
WORLD'S LARGEST EXCLUSIVE MANUFACTURERS OF FRACTIONAL HORSEPOWER GEARS



To keep "O" rings in place under pressure, use VIM *leather back-up washers*

For many years packing sets have included top and bottom support rings of the same or different material as the packings themselves.

This principle applies to "O" rings, which tend to extrude under high pressure. Our recommendation is to use VIM Leather Back-up Washers wherever pressures exceed 1500 PSI. Actually they are often used on lower pressures to prolong "O" ring life.

The leather washers absorb the oil medium, protecting and lubricating the ring. They keep the ring from extruding into the clearance. And they're relatively inexpensive.

You can buy both from Houghton

We supply *both* "O" rings and leather back-up washers in our complete line of hydraulic and pneumatic packings. Ask for Drawings S-7 and S-17 covering specifications. Or put your entire packing problem up to Houghton Engineers: many designers do. Write E. F. Houghton & Co., Philadelphia 33 and all principal cities.

HOUGHTON'S
VIM LEATHER and VIX-SYN PACKINGS

Build more "SELL" into your product with G-E components

Copyright Walt Disney Productions

Helping Donald Duck Make Sales!

Place paper in Donald's bill, press the button, and Donald zips through his work.

To add sales appeal to this interesting product—Universal Novelties equipped this appealing toy with a General Electric Flamenol* cord set.

Good-looking, hard-wearing Flamenol cord sets add style and eye appeal to cord-equipped products—tangible evidences of high quality—the extras that make a product stand out on the dealer's counter.

The Flamenol cord set's smooth, thermoplastic insulation cleans with a quick wipe. The plug construction makes for easy gripping. And these cord sets carry one of America's best known names—the confidence-inspiring General Electric trademark.

For more information on General Electric Flamenol cord sets, contact the G-E accessory equipment representative in your area, or write to Section Q43-567, Construction Materials Department, General Electric Company, Bridgeport 2, Connecticut.

THE G-E TAG provides extra sales help for products equipped with the General Electric Flamenol cord set. The big, General Electric monogram on this tag—and the brief description of the cord set—give a good sales talk for your product right at the point of sale. You can arrange to display the General Electric tag on every item you equip with the Flamenol cord set. Contact your G-E accessory equipment representative for details.

NEW HEATER CORD — From now on you'll hear a lot about the amazing new General Electric Preen-X heater cord. It's the heater cord that has more than ten times the abrasion resistance of ordinary heater cords—a heater cord that has no braid, nothing that can fray.

FLUORESCENT ACCESSORIES — Building a fixture using fluorescents? You'll find it pays to choose from General Electric's complete line of accessories for a better product, for better product acceptance. Famous Turret* lampholders and Watch Dog* starters—and a wide range of standard switches, sockets, and lampholders—are all part of the General Electric line.

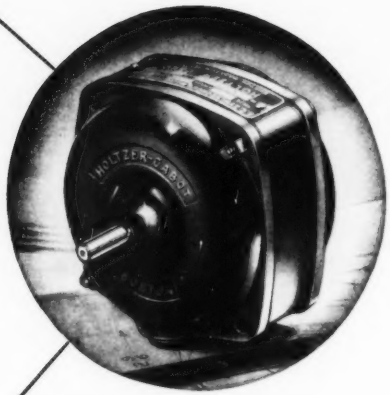
For further information, contact the General Electric accessory equipment representative in your area, or write to Section Q43-567, Construction Materials Department, General Electric Company, Bridgeport 2, Connecticut.

*Trade-mark Reg. U. S. Pat. Off.

GENERAL ELECTRIC

Flamenol CORDS

HOLTZER CABOT



FORERUNNER

Ten years ago Holtzer-Cabot instrument motors set a new standard in accuracy and compactness. Today, with ten years of refinement, these dependable products power many of the finest instruments throughout the world. Both synchronous and induction designs are in sizes up to 1/500th horsepower, gear head outputs down to 1 r.p.m. Many models can be secured from stock, or they can be built to special order. Write for complete information.

HOLTZER-CABOT, INC.

AFFILIATED WITH REDMOND COMPANY, INC.

BOSTON 19, MASSACHUSETTS

OFFICES IN NEW YORK, PHILADELPHIA AND CHICAGO

For applications such as Recorders, Industrial Process Controls, Tower Clocks, Timers and Traffic Controls.

DESIGNERS AND MANUFACTURERS OF FRACTIONAL HORSE-POWER ELECTRIC MOTORS FOR THREE-QUARTERS OF A CENTURY

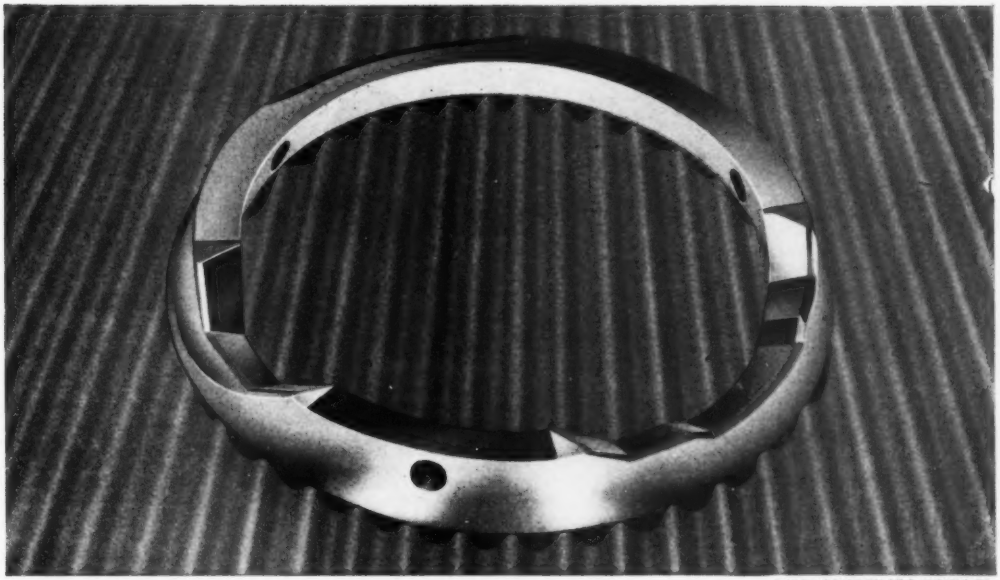


PHOTO COURTESY OF A. MILNE & CO.

Machines easier, lasts longer . . . made of TIMKEN® Graph-Mo steel

THIS cam is used to guide the needles in a hosiery knitting machine. Because no lubrication is possible and the slightest wear would throw the needles out of kilter, the cam must be made of exceptionally hard steel.

Oil hardening tungsten steels, originally tested, proved difficult to machine, extremely brittle, and frequently distorted in hardening.

Then the manufacturers tried Graph-Mo—one of the five Timken® graphitic tool steels. Because Graph-Mo contains free graphite in its structure, cams are now machined faster and easier. Contours are finished to precision tolerances, free from scuffing and scoring. Due to uniform response to heat treatment, distortion in hardening is prevented. And because Graph-Mo contains diamond-hard carbides, cams now offer stubborn resistance to wear.

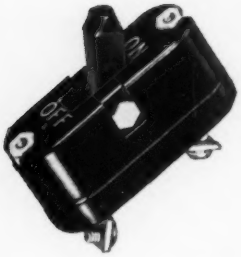
Textile machine manufacturers also report exceptional performance from Graph-Mo punches and dies, used for making knitting machine needles.

Why not investigate Timken graphitic steels for your products today? Write for our 48-page, fact-packed, illustrated booklet, "Timken Graphitic Steels". The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, O. Cable address: "TIMROSCO".

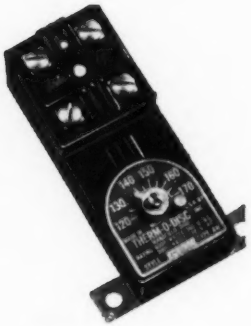
YEARS AHEAD—THROUGH EXPERIENCE AND RESEARCH

Specialists in alloy steel—including hot rolled and cold finished alloy steel bars—a complete range of stainless, graphitic and standard tool analyses—and alloy and stainless seamless steel tubing

The reasons improved RESINOX was specified here may be important to you!



Klixon Built-in Motor Protectors and Circuit Breakers guarantee trouble-free performance through use of heat resistant, inert, electrically superior Resinox. By Spencer Thermostat Division, Metals & Controls Corporation, 34 Forest St., Attleboro, Mass.



Therm-O-Disc over-temperature protective thermostat, a precision molding job, will withstand surges up to 10,000 volts . . . and Therm-O-Disc snap action thermostat gives unfailing protection on many applications—both molded of Resinox by Therm-O-Disc Incorporated, 127 Crouse St., Mansfield, Ohio.

As the twin calipers of *costs* and *performance* are laid on your job today, you will find yourself coming to standardize more and more on Resinox.

For in addition to the many well-known advantages of this veteran Monsanto thermo-setting molding compound, recent formulation improvements have yielded:

Shorter cure and thinner cut off

Improved mold release

Better flow

Better appearance

To manufacturers caught in the squeeze between high production costs and growing consumer resistance . . . the twin opportunities for faster production and better performance are vitally important.

Check with your Monsanto representative about improved Resinox formulations...or send in the handy coupon below.

MONSANTO
CHEMICALS—PLASTICS

SERVING INDUSTRY . . .
WHICH SERVES MANKIND

Resinox: Reg. U. S. Pat. Off.

MONSANTO CHEMICAL COMPANY, PLASTICS DIVISION
Dept. PEP-17, Springfield 2, Mass.

Please send me full information on Resinox for my products.

Name Title

Company

Products Manufactured

Address

City Zone State

Close tolerances in resilient gaskets are seldom necessary

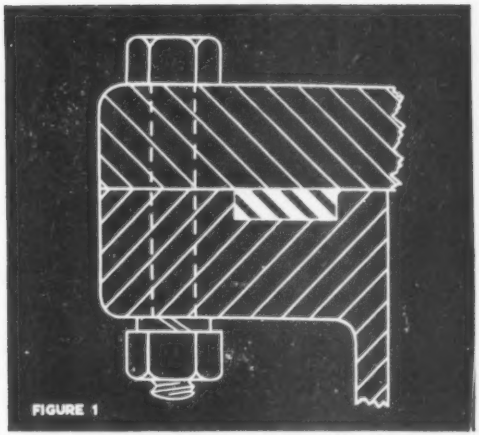


FIGURE 1

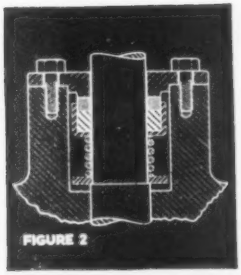


FIGURE 2

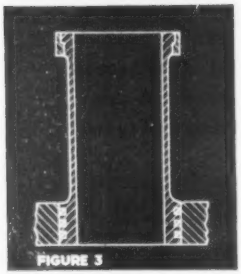


FIGURE 3

Close tolerances in resilient gaskets are a luxury that is seldom justified. Even units with extremely close assembly tolerances can usually be sealed with gaskets made to commercial standards . . . provided the design of the unit and the choice of gasket material are in harmony.

In figure 1, for example, close assembly tolerances can be maintained. Yet the gasket can vary over a relatively wide range of thicknesses if it has been cut from a truly compressible material like Armstrong's cork-and-rubber. Because these materials decrease in volume under load, they compensate for tolerance variation.

When rubber was used as a packing ring in figure 2, close tolerances were necessary to prevent high radial pressure. A factory-lubricated cork-and-rubber ring was substituted. Made slightly undersize to insure a tight seal, cork-and-rubber compresses enough to maintain low radial pressure.

To seal the cylinder liner in figure 3 with molded rubber rings, extremely close tolerances were required. Undersize rings leaked. Oversize rings tended to split the sleeve. A slightly oversize cork-and-rubber ring was tried. Fitting snugly into the groove, it sealed tightly. And there was no danger of splitting the sleeve.

Available in 17 different formulations, Armstrong's cork-and-rubber combines truly compressible cork particles and non-compressible synthetic rubbers in a wide range of compressibilities. To suit particular sealing requirements, these gasket materials may be used with compressions ranging from 10% to 50%.

Versatile cork-and-rubber can help solve your sealing problems. We recommend that you discuss your application with an Armstrong representative. He can suggest suitable materials and supply samples for experimental use.

Send for this Gasket Handbook

You'll find useful application and specification data in the new, enlarged 24-page booklet, "Armstrong's Gasket and Sealing Materials." It contains up-to-date data on synthetic rubber, cork-and-synthetic-rubber, cork composition, and fiber sheet sealing materials.

This booklet includes ten technical discussions of the factors influencing modern gasket and joint design. It also suggests methods of putting Armstrong's stock materials to specialized uses in such fields as radio, electrical, automotive, petroleum, and transportation industries. Also included are typical applications and current government specifications.

For your free copy, fill in coupon and mail today. Available for export.

ARMSTRONG CORK CO.
Gaskets and Packings Dept.
7105 Arch Street, Lancaster, Pa.

Please send me at once a copy of the new 24-page booklet, "Armstrong's Gasket and Sealing Materials."

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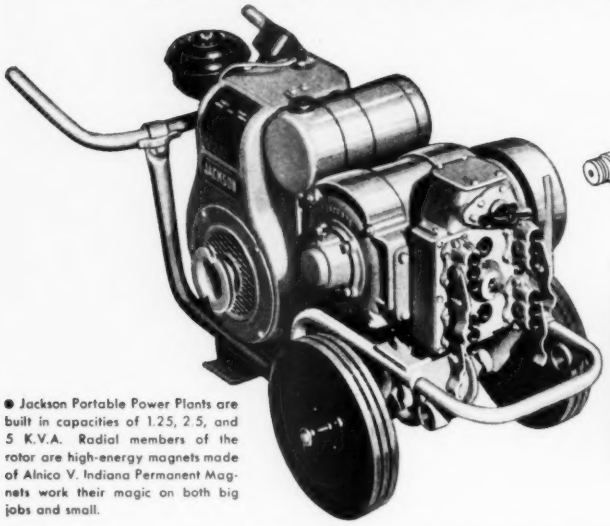
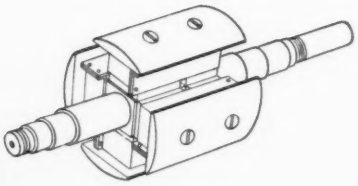
ARMSTRONG'S
GASKETS • PACKINGS • SEALS

THIS PERMANENT-MAGNET ROTOR MEANS RELIABLE ROUND-THE-CLOCK POWER





● Jackson Portable Power Plants are built in capacities of 1.25, 2.5, and 5 K.V.A. Radial members of the rotor are high-energy magnets made of Alnico V. Indiana Permanent Magnets work their magic on both big jobs and small.

121 FEWER PARTS... LESS MAINTENANCE WITH INDIANA PERMANENT MAGNETS

121 fewer parts in a better, *more dependable* generator! That's what Indiana Permanent Magnets have done for Jackson Portable Power Plants. The rotor now is a permanent magnet field. There are no brushes or collector rings . . . no commutator sparking or arcing. Less heat is developed. Over-all size and costs are reduced. Maintenance is minimized. Here, again, modern design with Indiana Permanent Magnets is a *product plus* that pays.

INDIANA PERMANENT MAGNETS MAY BE YOUR ANSWER, TOO!

For four decades, the pace-setting design techniques at Indiana have made possible *new and better* permanent magnets. And, on countless different products, this versatile "packaged energy" improves performance, permits new functions, saves space *and money* . . . as mechanical force in holders and separating devices . . . in transforming electrical energy into mechanical motion, and vice versa . . . in changing the apparent characteristics of materials. Indiana offers you the *experience and know-how* of more than 30,000 different applications. Let's get our engineers together on *your* problems. Write today.

Free Book for Designers

Ask for free Book No. 4-B5—our new permanent magnet reference manual. A note on your company letterhead will bring a copy to your desk.

INDIANA PERMANENT MAGNETS

THE INDIANA STEEL PRODUCTS COMPANY

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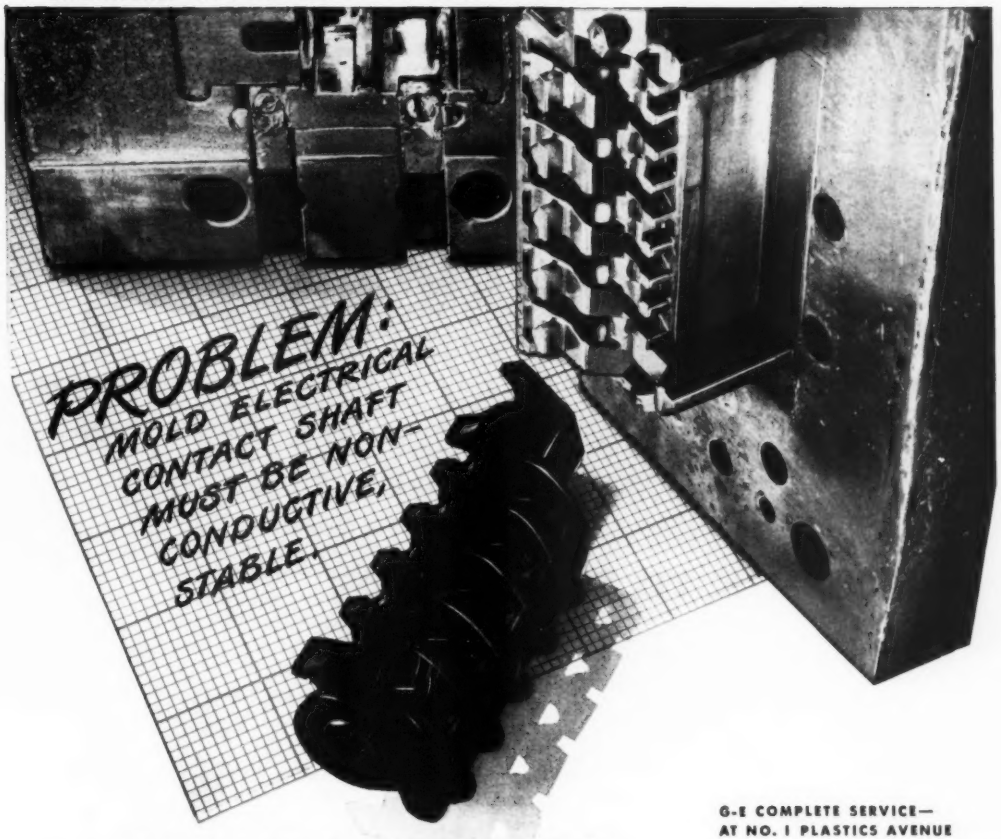
SPECIALISTS IN "PACKAGED ENERGY" SINCE 1908

•ENGINEERED IN PLASTICS BY GENERAL ELECTRIC



Plastics do the "impossible"

To make this electrical contact shaft out of any single material seemed impossible—until plastics came into the picture. General Electric plastics engineers designed this piece of control equipment so that several functions were combined in the one part—and important savings resulted.

Molded by G. E. of phenolic plastics, the contacter shaft furnishes its own insulation. It is dimensionally stable; the contacts remain in perfect alignment. Shock resistant and durable, the part gives excellent service. Plastics even serve as a bearing in an aperture at the end of the piece, in which a steel shaft moves.

Here is just one more example of how General Electric's *complete* plastics service provides the design, engineering, and molding facilities which can improve a product.

Write us for more information, or contact your nearest G-E sales office. We'll be glad to send you, free, the informative booklet, "Design Data on Plastics." Address: Plastics Division, Chemical Department, General Electric Co., 1 Plastics Ave., Pittsfield, Mass.

G-E COMPLETE SERVICE—AT NO. 1 PLASTICS AVENUE

Backed by 54 years of experience. We've been designing and manufacturing plastics products since 1894. General Electric research facilities have expanded continually, working to develop new materials, new processes, new applications for plastics parts.

No. 1 Plastics Avenue—complete plastics service—engineering, design, mold-making. G-E industrial designers work with our engineers to create plastics parts, sound and good looking. Skilled mold-makers in G-E toolrooms average over 13 years experience.

All types of plastics. Compression, injection, extrusion, transfer and cold mold facilities...high and low pressure laminating . . . fabricating. G-E Quality Control—a byword in industry, means as many as 160 inspections for a single plastics part.

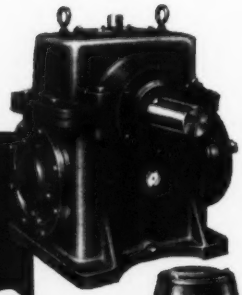
You can put your confidence in

GENERAL ELECTRIC

CD49-105

General Electric plastics factories are located in Meriden, Conn., Coshocton, Ohio, Decatur, Ill., Taunton and Pittsfield, Mass.

Foote Bros. Hypower Enclosed Worm Gear Drives assure economy in original cost and economy in operation. They bring a new compactness in design plus greatly increased thermal capacity. Available in vertical and horizontal types.



Foote Bros. Straight Line Enclosed Gear Drives will shortly be introduced. These compact units may be used with any standard motor. Ratios range from 5 to 240 to 1.

looking for drives?

THEN LOOK TO FOOTE BROS.

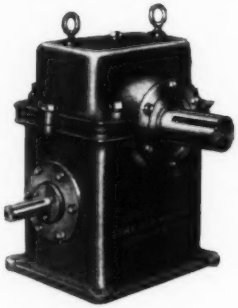
Foote Bros. Hytop Enclosed Worm Gear Drives provide wider low-speed bearing span. Ideal for installation where low-speed shaft extensions cannot be supported by pilot or guide bearings at the end of shaft. Available in both Hygrade and Hypower types.

If you require enclosed gear drives, the Foote Bros. line offers a wide variety of types, sizes and ratios to meet any need.

Nearly a century of engineering and manufacturing experience is back of Foote Bros. Drives. Two large plants contain the newest in gear generating equipment—new techniques in manufacture—better metallurgical control of materials—improved manufacturing methods—all assure you superior enclosed gear drives.

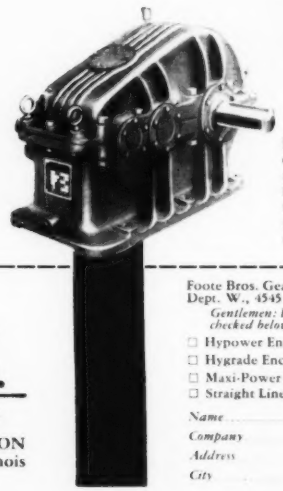
Mail the coupon for information.

Foote Bros. Hygrade Enclosed Worm Gear Drives have been newly engineered and now offer the maximum in rugged dependability. Specially designed for heavy-duty applications. Available in both horizontal and vertical types.



AVAILABLE FROM STOCK

A new policy of distribution now makes Foote Bros. Enclosed Worm Gear Drives available from stock. A range of sizes and ratios is offered to meet many industrial applications.



Foote Bros. Maxi-Power Helical Gear Drives are available in single, double and triple reductions. A newly engineered line that represents the last word in modern power transmission equipment.

FOOTE BROS.

Better Power Transmission Through Better Gears

FOOTE BROS. GEAR AND MACHINE CORPORATION
Dept. W, 4545 S. Western Blvd., Chicago 9, Illinois

Foote Bros. Gear and Machine Corporation
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Gentlemen: Please send me information on drives checked below:

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- ☐ Hygrade Enclosed Worm Gear Drives
- ☐ Maxi-Power Enclosed Helical Gear Drives
- ☐ Straight Line Enclosed Gear Drives

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Company .....
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gramix gears

help this mechanical counter run for years without a miss!

The Silver King Mechanical Counter manufactured by The Production Instrument Co., of Chicago, meets the exacting requirements of industry for accuracy and dependability. It keeps right on counting, year after year, without a miss. Two good reasons why this practical counter *operates without maintenance* are the two Gramix Gears that form the heart of the machine. They are roughly equivalent to the transmission on a car. Not only do they do their appointed job unfailingly, but *their original cost is but a fraction* of that of the machined parts formerly used in the instrument. Gramix parts are precision-pressed from powdered metals and require no costly machining and hand finishing. The lubrication is impregnated right into the processed metal and never needs additional oil. Gramix powdered metal bearings, bushings, gears and machine parts *can be made in any practical size and shape.* Perhaps we can show how Gramix can help you maintain the dependability of your product and at the same time greatly reduce your cost of manufacture. Send us your prints for specific recommendations and ask for the 264 page Gramix catalog.

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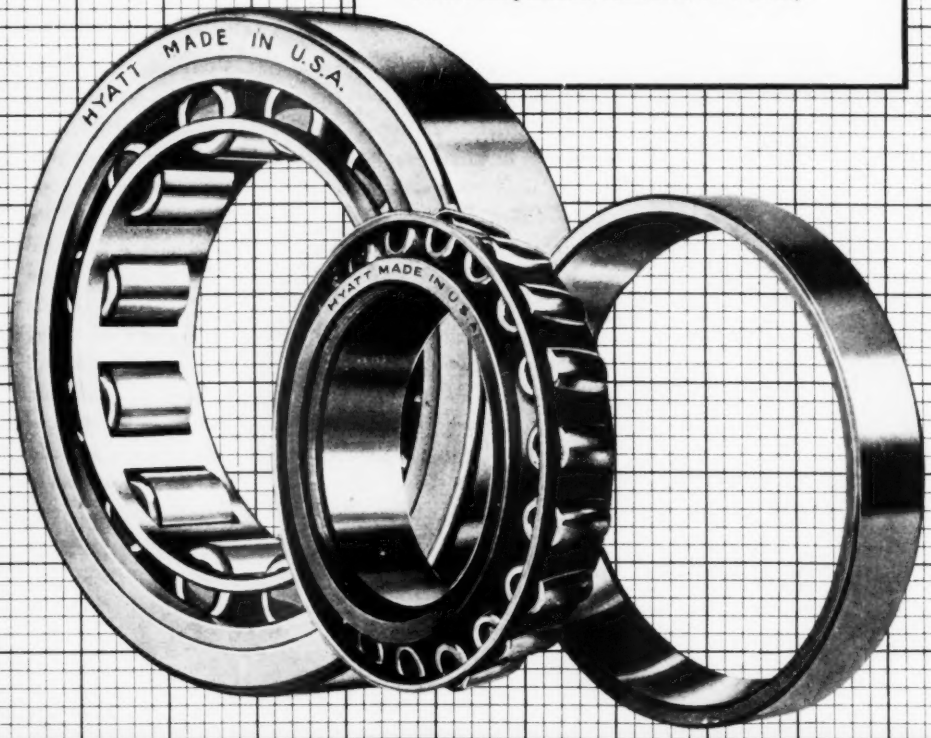
From the *first* roller bearing available to industry, to the millions now produced annually, Hyatt Roller Bearings have been built to *last*.

For over half a century, Hyatts have been designed into vital positions of all types of mechanical equipment and over the years these dependable Hyatt bearings have run up unmatchable performance records wherever they are in use.

Your selection of Hyatts is an assurance of complete satisfaction to all concerned in the building and operation of modern machines and equipment. Hyatt engineering service is yours on request. Hyatt Bearings Division, General Motors Corporation, Harrison, New Jersey.



HYATT ROLLER BEARINGS

VAN HUFFEL

continuous rolled

METAL SHAPES AND TUBING

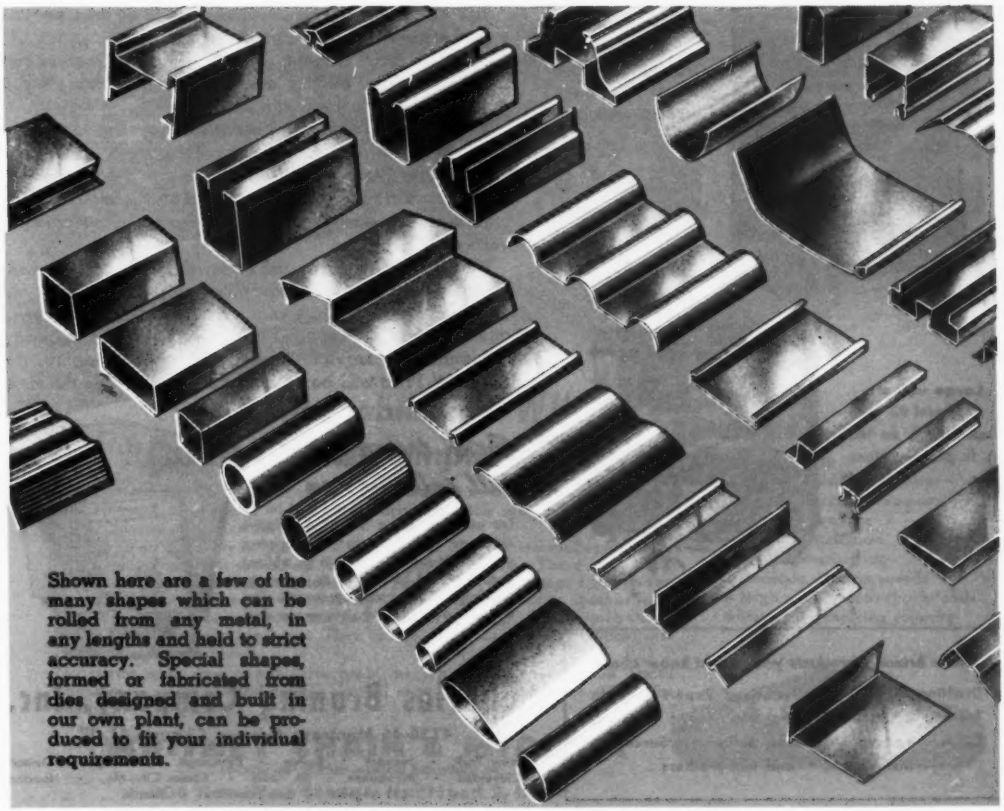
WELDED • LOCK SEAM • OPEN SEAM • BUTTED

For over forty-seven years Van Huffel has been designing and building cold forming mills and dies as well as rolling metal shapes, mouldings and tubing from Hot or Cold Rolled Steel, Stainless Steel, Copper, Brass, Bronze, Aluminum, Zinc, etc. in gauges UP TO 5/16 inch.

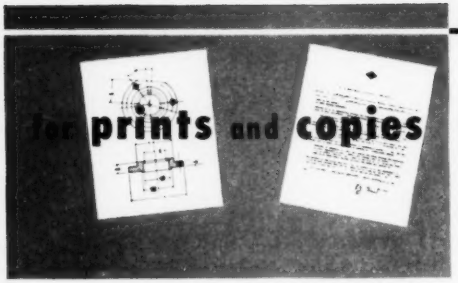
This "under one roof" procedure, supervised by engineers whose expert knowledge of uses—both structural and functional—which rolled tubing and shapes can serve, assures you of rigid control throughout the various phases of manufacture.

As competition brings demands for simplification of parts and lowering costs we invite you to consult us on the possibility of doing the job better and more economically through the use of continuous rolled metal shapes or tubing.

VAN HUFFEL TUBE CORPORATION • WARREN • OHIO



Shown here are a few of the many shapes which can be rolled from any metal, in any lengths and held to strict accuracy. Special shapes, formed or fabricated from dies designed and built in our own plant, can be produced to fit your individual requirements.



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exact

use

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A size for every need

Limited volume
The Bruning Whiteprinter Model 11
(not illustrated)

Small volume
Model 21
Capacity of 3,000 8½ x 11 sheets daily. Takes roll stock, too.

Moderate volume
Model 41
Capacity up to 24½ sq. ft. per min. Fully automatic.

Large volume
Model 93
Capacity up to 105 sq. ft. per min. None finer.

The Body Engineering Department of a well-known auto maker uses precise BW Prints for large body drawings. Some of these drawings are 18 to 20 feet long, yet are amply true to scale. (The department also makes precise BW Prints of all body detail drawings.)

BW Prints are precise because there is no intermediate step between the original drawing and the print. No chance for error to creep in. The direct BW Process can never transpose, add, or delete material—except as you deliberately alter the original.

BW Prints are precise because they are *positives:* there is no reversing of values. Hence BW Prints normally show black or colored lines against a white or tinted background. Tests prove that these are more legible—more easily understood than are negatives—such as blueprints.

BW Prints stay sharp and clear—never smear or offset. No inks, stencils, or photographic emulsions are used, no chemicals which require ventilation or which bleach your other prints. BW Prints are delivered flat and dry—ready for immediate service. And regardless of quantity, the final BW Print will be as sharp and precise as the first.

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Let us send you a file of descriptive literature on Bruning Whiteprinters and BW Materials. There is no obligation. It would be helpful to know approximately how many copies you plan to make a day and their average size.

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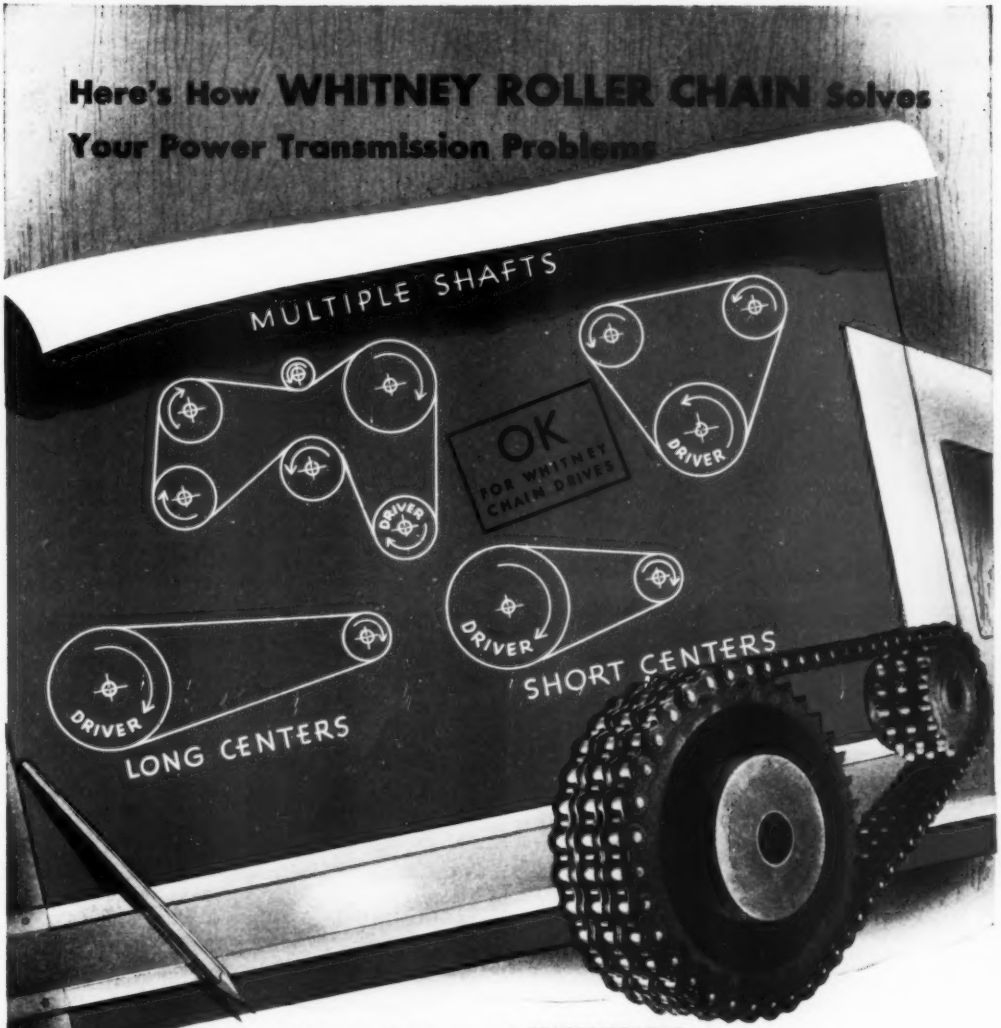
Here's How WHITNEY ROLLER CHAIN Solves Your Power Transmission Problems



Adaptability of WHITNEY ROLLER CHAINS Simplifies Designs

Whitney Chain drives should be considered as flexible gearing, and, as such, they offer a wide range of drive selection and adaptability to all types of applications.

The versatility of Whitney Chain enables you to drive shafts clockwise or counterclockwise all from one power source. These alloy steel Whitney Chain drives deliver *full power* without slippage from power source to driven elements. They can be operated slack on short or long centers. They do not impose excess loads on shaft bearings. They absorb shock and overloads without breakage. They can be put on or taken off without disconnecting shafts or gears.

No matter what your power drive problems Whitney Chains and Cut Tooth Sprockets . . . *the all-steel drives* . . . will meet your requirements. Write for complete details, today.

CHAIN DRIVE IS BETTER

- Positive grip
- Transmits full horsepower
- Simplifies transmission designs
- Low maintenance
- Ease of installation
- Long operating life
- Constant uniform speeds
- High resistance to shock loads
- High load carrying capacity

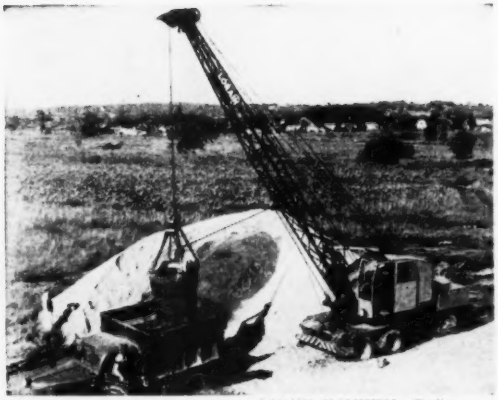
WHITNEY CHAIN & MFG. CO.

DIVISION OF WHITNEY-HANSON INDUSTRIES, INC.

204 Hamilton Street, Hartford 2, Conn.

TAGLINES OR DIPPER-TRIPS--

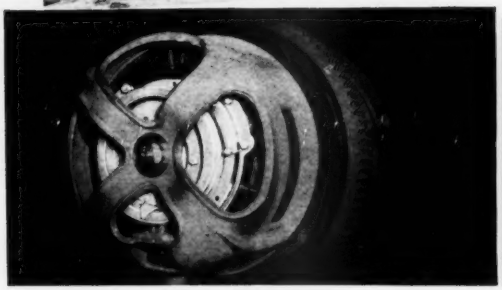
WARNER ICB UNITS* GIVE YOU FASTER, MORE ACCURATE CONTROL



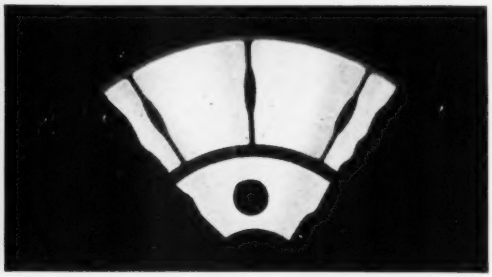
LORAIN CLAMSHELL. Tagline Controlled by Warner ICB Unit.

LORAIN SHOVEL — Warner ICB Unit equipped

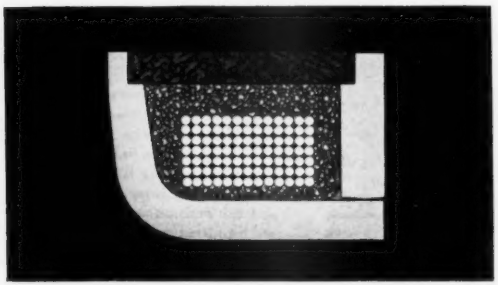
THEW-LORAIN SHOVELS AND CRANES USE a Warner Electric Industrial ICB Unit* on the tagline and dipper-trip reel. It continuously maintains exact tension to precisely position a clamshell or magnet and keep them steady without twisting. Flexibility of control permits a larger working area without repositioning machine or boom. When used with a shovel — it keeps dipper-trip line constantly taut and trips dipper at finger touch.



WARNER ICB UNIT* AS INSTALLED on Thew Shovel. Note simple compactness, easy accessibility. ICB Units are self-adjusting for life. Push-button and rheostat give instant finger-tip control. There's a complete range of sizes to meet various requirements for positive acting, sensitive controlled clutches or brakes for industrial use.



ARMATURE SECTION: One of only two parts for either Clutch or Brake actuating units. Consists of magnetic segments welded to steel back-plate (see cut). Especially designed for high heat dissipation. Heat has no effect on unit efficiency because segment expansion is always linear . . . thus keeping full magnet contact at all times.



MAGNET SECTION: The other of the two parts for either Clutch or Brake actuating units. Consists of electro-magnet faced with long-wearing, high friction material. Power, applied through coils imbedded below (see cut) uses both friction plus magnetic attraction for lightning fast, super-powerful clutch or brake action.

● Warner ICB Units* are low-cost key to more automatic, safer operation of wide variety of motors and machinery . . . give you infinite control of degree of clutch or brake action. For details or engineering assistance write: **Industrial Division, WARNER ELECTRIC BRAKE MFG. CO., Beloit, Wis.**

WARNER
ICB UNIT*

*ICB Unit — The trade designation for The Warner Electric INDUSTRIAL CLUTCH OR BRAKE UNIT.

Taking a broad view in Plastics

Porto-Sight Binoculars Molded for Porto-Sight Company, Kansas City, Mo.

Kodachrome of Banff, Alta., courtesy Canadian Pacific Railroad Co.

These Porto-Sight binoculars for which we molded both lenses and housings are a striking illustration of our ability to skillfully create new plastic products. Here was a new idea—planned to fill a long standing demand for lightweight, pocket size binoculars. To create such a product, our engineers and molding technicians had to solve difficult new problems in weight, functional stability and optics.

Thus we succeeded in producing sturdy binoculars weighing less than 2 ounces and with the highest optical power of any within a similar price range.

We have developed a special technique vital to the success of any new plastic product: This technique results in our ability to choose *correct* plastic materials and to mold them skillfully and at low unit production cost.

Our knowledge can help you turn your ideas for new plastic products into profitable reality. Take the first step toward those profits—consult us today. No obligation of course.

Write on your letterhead for the new Injection Molded and Extruded Plastics Catalog. Or, for detailed information about [redacted]* piping, tubing and fittings, write for circulars containing data and illustrations.

*Trademark Registered

ELMER E. MILLS CORPORATION

INJECTION MOLDERS and EXTRUDERS of: Tenite, Lumarith, Plastacele, Fibestos, Lucite, Plexiglas, Nylon, Polystyrene, Styron, Lustron, Loalin, Vinylite, Geon, Plexene, Polyethylene, Cerex, Forticel, [redacted]*, Saran, and other Thermoplastic Materials

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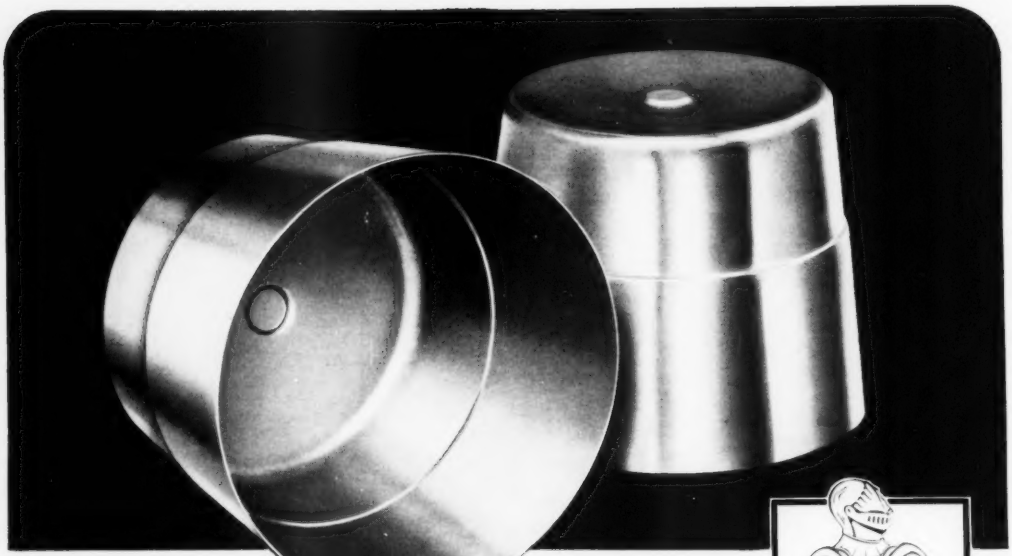

Ingenuity...

This appears to be a simple stamping. However, the combination of the tapered shape and the light gauge material makes it difficult to draw without wrinkles. Once introduced, it is almost impossible to eliminate a wrinkle.

Carefully planned tooling — the correct number of preliminary operations, plus an ingenious reverse draw — solved this difficult stamping problem.

Result... uniform parts with a minimum of die marks, permitting economical preparation of the surface for high lustre plating and polishing.

WORCESTER PRESTEEL

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ALLOY STEELS AND OTHER METALS COLD FASHIONED SINCE 1883

PRECISION METAL STAMPINGS FOR EVERY TYPE OF INDUSTRY

WORCESTER PRESSED STEEL CO.

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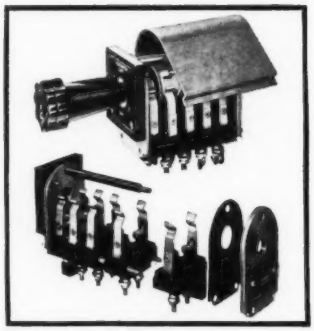
ALLIS-CHALMERS OFFERS EQUIPMENT

Facts about A-C ALLIS-CHALMERS control

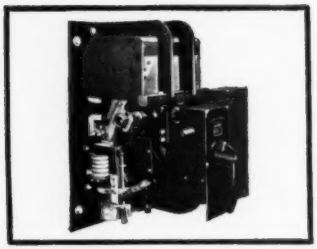
Pictured here is *part* of Allis-Chalmers wide line of switchgear and control devices... being advertised for the first time to designers! Now, you can get high quality control devices from the *same* O.E.M. supplier who offers the widest range of V-belt equipment—Texrope—as well as a-c and d-c motors from ½ hp up. For a choice of over 1600 *industry accepted products*, make your headquarters Allis-Chalmers!

Texrope is an Allis-Chalmers trademark



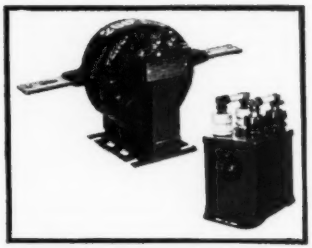
ROTARY CONTROL SWITCHES

Here's a new type rotary control switch especially designed for rough repetitive service. Solid, positive contact motion is achieved through use of square shaft and star-holed contact segments. For ammeter, voltmeter, frequency meter, P. F. meter, circuit breaker, and many other uses. Continuous rating 10 amps, at 600 Volts.



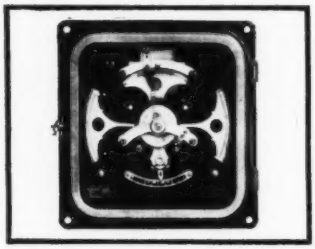
AIR CIRCUIT BREAKERS

Manually or electrically operated for service up to 600 volts a-c. Inverse time series overcurrent trip permits adjustment of overload setting from 100% to 200% of breaker ampere rating, and adjustment of time delay. Also open and enclosed types for individual wall mounting. Type G-25 rated 25,000 RMS amp interrupting capacity; 50 to 600 amp; 600 volts a-c. Type G-50 rated 50,000 RMS amp interrupting capacity; 200 to 1600 amp; 600 volts a-c.



CURRENT AND POTENTIAL TRANSFORMERS

Circular shaped current transformer coils prevent distortion under heavy overcurrents. Flat conductors, accurately formed are hand wrapped with the finest grades of insulating tapes. Construction of potential transformers is compact and strong. Coils are thoroughly impregnated under a vacuum pressure process, insuring a solid coil which is impervious to moisture.



GENERATOR VOLTAGE REGULATORS

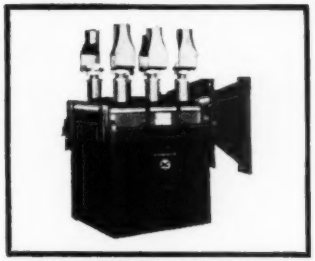
For dependable, smooth, sensitive voltage regulation, you can depend on Allis-Chalmers rocking contact regulators. The principle of *rocking* the field resistance contacts produces smooth, almost frictionless resistance changes. Because of only slight mechanical movement, response is quick with very little bearing wear. Eight type sizes are available for control of a-c and d-c generators of all ratings.

Pioneers in Power and Electrical Equipment From Generation Through Utilization

ALLIS-

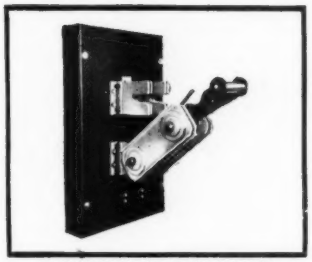
AID TO ELECTRICAL DESIGNERS!

and switchgear devices



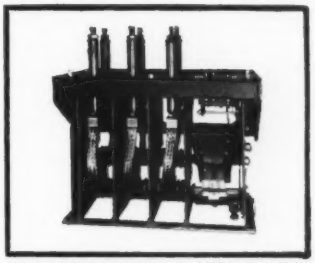
OIL CIRCUIT BREAKERS

Designed for control and protection of generators, feeder circuits, and transformer banks. Available in fully automatic, or non-automatic; manually or electrically operated. Ratings from 15,000 to 50,000 kva interrupting capacity; up to 7500 volts and 1200 amps. Also available are special oil circuit breakers for use in auto transformer circuits of large motor starters; manually operated.



DISCONNECT SWITCHES

Hook stick operated switches rated up to 2000 amp for either panel or framework mounting. Five thousand to 15,000 volts; 600, 1200, and 2000 amps. Also heavy duty clamp type switches for higher load concentrations. Available in panel mounting or unmounted, manual or hook stick operated. Up to 600 volts a-c; 3000 to 6000 amp; 750 volts d-c; 2000 to 10000 amp.



OIL IMMERSED CONTACTORS

Designed for heavy duty motor starting in industrial plants. Contact pitting is reduced by means of improved contact mechanism in which moving contact wipes and rolls with each operation. For use on full and reduced voltage squirrel cage and synchronous motor starters. Maximum ratings 200 amp; 1500 hp at 2300 volts. Interrupting ratings — 10 times full load motor current.

PUSH BUTTON STATIONS

Functional design plus pleasing appearance make these push button stations ideal for almost any industrial use. Available in light duty surface mounting, and heavy duty flush or surface mounting in hundreds of combinations. Ratings up to 600 volts a-c maximum.

All start buttons are encased in shrouds to prevent accidental starting, and locking bars are available so that buttons can be locked in the "stop" position. Delivery from stock.

SEND TODAY

for new 16 page bulletin 2587095 covering Allis-Chalmers switchgear and control devices. It's filled with useful engineering information, including ratings and capacities. Illustrates over 75 control items.

ALLIS-CHALMERS, 1002A SO. 70 ST.
MILWAUKEE, WIS.

Please send me the literature checked below:

- Switchgear and Control Devices—Bulletin 2587095 ☐
- Rotary Control Switches—Catalog Section 6162 ☐
- Push Button Stations—Catalog Section 6128 ☐
- Generator Voltage Regulators—Catalog Section 2485 plus Bulletins B6143, B6015A, 146035, B6137 ☐
- Current Transformers—Catalog Sections 2801 to 2817 ☐
- Potential Transformers—Catalog Sections 2820 to 2828 ☐
- Disconnect Switches—Catalog Section 2591 ☐
- Oil Immersed Contactors—Catalog Section 6144 ☐
- D-C Relays and Contactors—Catalog Sections 6164 and 6142 ☐
- Thermal Relays—Catalog Section 6140 ☐
- D-C Remote Positioning Devices—Bulletin 1486641 ☐
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- Pre-Engineered Texrope Drives—Bulletin 2086956 ☐
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CHALMERS

Worrying about *VIBRATION FATIGUE?*

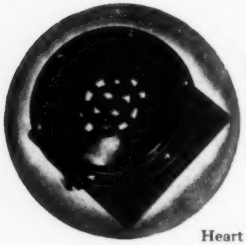
Read how these 5 metal-selection problems were solved

VIBRATION FATIGUE ... notorious destroyer of springs and working parts ... is doubly difficult to defeat when the design picture is complicated by corrosion, extreme heat or cold.

Many manufacturers have found a time-tested solution to this problem in the family of INCO Nickel Alloys. These "task metals" put at your command a unique combination of physical properties ... high strength, excellent corrosion resistance, good thermal endurance, and outstanding resistance to vibration fatigue.

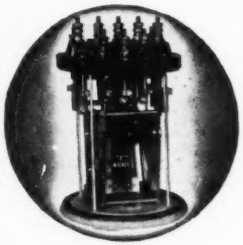
Perhaps one of the five examples shown will suggest a solution to your own problems. If not, our Technical Service Department will gladly make recommendations based on years of metal research and a vast fund of practical experience data.

Write for your free copy of the helpful new booklet: *"66 Practical Ideas for Metal Problems in Electrical Products."*



SIGNAL HORN

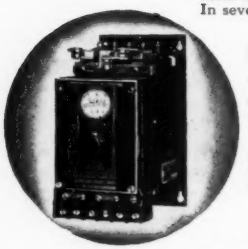
Designed for use in factories where moisture and corrosives might be present, the diaphragm of this horn had to be corrosion-resistant as well as vibration fatigue-resistant. Edwards & Co., Norwalk, Conn., chose *Inconel** for the job and has received no reports of horn failures even from plants where corrosive fumes are constantly present.



CODE TRANSMITTER

Heart of this instrument is a pendulum-type armature which vibrates continuously at 180 times a minute, 94 million times a year. The transmitter controls code impulses to railway signals and engine cabs, showing traffic on the rails at any moment. To insure dependable operation, the armature must be a good electrical conductor, and have high resistance to fatigue failure.

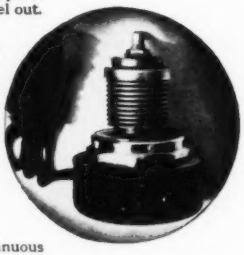
Union Switch and Signal Company states: "'Z'* Nickel proved to be an ideal metal for armatures because it offers maximum resistance to fatigue. In several years' experience, none has been known to break."



INDUSTRIAL TIMER

This Series "2800" Timer gives split-second control of many industrial operations. A particularly critical part of the design was a shock absorber which cushions the operating impact of a solenoid plunger.

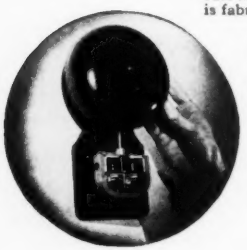
After several fatigue-resisting alloys had failed at the million mark in flexing tests, engineers of the Automatic Temperature Control Co., Inc., standardized on "Z" Nickel for the shock absorber. Tests and field reports show that more than five million blows have failed to knock "Z" Nickel out.



BELLOWS

For operating automatic switches controlling temperature and pressure in refrigerating systems, these bellows had to be both corrosion-resistant and proof against failures caused by constant flexing.

The Fulton Sylphon Co. chose Monel* for this job ... and solved a difficult metal problem. The bellows are made from .050" sheet Monel, which is fabricated into a tube .0065" thick.



WARNING BELL

To guarantee emergency performance, and at least 1,000 hours of continuous use, the flat reaction spring of this bell required a metal that was both corrosion and fatigue resistant.

Tests showed that some metals lasted only a few hours. But "Z" Nickel performed perfectly after 2,600 hours of continuous service.

In addition, to prevent corrosion freezing within the bushing, the plunger which strikes the bell is made of Monel.

THE INTERNATIONAL NICKEL COMPANY, INC. • 67 Wall Street, New York 5, N.Y.

EMBLEM OF SERVICE

NICKEL INCO ALLOYS MONEL* • "K" MONEL • "S" MONEL • "R" MONEL • "KR" MONEL • INCONEL* • NICKEL • "L" NICKEL • "Z" NICKEL

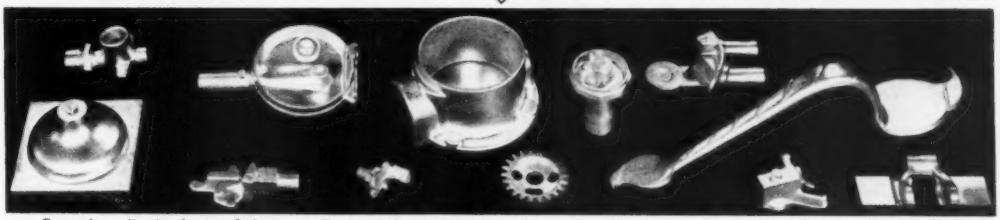
Reg. U. S. Pat. Off.

COPPER ALLOY BULLETIN

PRODUCT IMPROVEMENT EDITION

REPORTING NEWS AND TECHNICAL DEVELOPMENTS OF COPPER AND COPPER-BASE ALLOYS

Prepared Each Month by Bridgeport Brass Co. **"Bridgeport"** *Headquarters for BRASS, BRONZE and COPPER*



Copper-base alloy hot forgings find many applications in both engineering and decorative fields. Courtesy Accurate Brass Company, Glendale, N. Y.

Copper-Base Hot Forgings Find New Markets

Bigger, more powerful presses, tool steels capable of withstanding red-hot working temperatures and high pressures, clever tool designing and a wider range of copper-base alloys have all aided materially to the rapid advancement in hot forging.

Brass still takes the lion's share of the copper-base alloy forging business, but high-strength, corrosion-resisting engineering alloys, such as Silicon Bronze and Aluminum Bronze, have opened new avenues to designers.

Hot forgings for engineering applications have replaced sand-castings because of superior strength, greater density, freedom from porosity and more accurate dimensions. They are ideal for pressure pipe fittings, valves and controls for pressure vessels, propellers, pump components, wheels, gears, cams, fire fighting equipment, surgical and dental instruments, etc.

Now hot forgings have invaded the quality field of decorative items which call for attractive designs and highly-polished, beautiful finishes. Among these are: hardware items — door knockers, handles, lock parts, hinges and clothes hooks; candlesticks, frames, flanges, ornaments and novelties.

The service life of valves, pump parts, controls, hydraulic systems, etc., can often be increased by using hot forgings from Duronze III silicon aluminum bronze. This alloy has greater resistance to corrosion and wear and is stronger than most metals and alloys. Hot forgings average about 90,000 psi. Its high yield strength, fatigue and wear resistance values are desirable assets for engineering applications.

In the field of pole line hardware, Duronze III and Silicon Bronze No. 632 forgings are also helpful in cutting down excessive weight through improved physical properties. Their resistance to corrosion from weathering makes them excellent for outdoor construction and for use in equipment for water works, sewage and waste treatment plants.

Laboratory Service

Customers, trying to effect economies in fabrication, can call on our laboratory for help in selecting the alloy and temper which will serve best. Contact our nearest District Office for any service we can render—or write for the Bridgeport Technical Handbook.

HOT FORGING RODS		Bpt. Forging Rod 133	Naval Brass 24	Manganese Bronze 19	Muntz Metal 14	Duronze III 707	Duronze II 1232
Copper	%	59.50	60.0	58.5	59.75	91.0	97.05
Lead	%	1.75	.15				2.85 Silicon
Tin	%	.20	.75	0.75			0.12 Iron
Zinc	%	38.55	39.1	39.45	40.25		
Iron	%			1.0		7 Aluminum	
Manganese	%			.3		2 Silicon	
Ten. Strength psi	Hard*	72,000	80,000	83,000	72,000	100,000	90,000
	Soft	52,000	55,000	72,000	54,000	85,000	55,000
Yld. Strength psi (@ ½% extens. under load)	Hard*	50,000	52,000	55,000	50,000	50,000	
	Soft	20,000	25,000	30,000	21,000	45,000	
Elongation % in 2"	Hard*	50	15	25	52	10	18
	Soft	45	50	45	50	30	55
Rockwell Hardness	Hard*	B78	B78	B85	B78	B95	B85
	Soft	F78	B50	B55	F80	B85	B50
MECHANICAL PROPERTIES AS HOT FORGED							
Ten. Strength psi			60,000			90,000	60,000
Yld. Strength psi			25,000			45,000	24,000
Elongation % in 2"			35			30	70
Rockwell Hardness			B52			B85	B35
Machinability Rating**		80	30	30	40	60	20
Cold Working		F	F	P	F	P	E
Hot Working		E	E	E	E	E	E
Hot Working Range °F		1200—1500	1200—1500	1150—1300	1150—1450	1300—1600	1350—1550

*Hard temper—values are for rod of commercial hard drawn temper. **Machinability Rating—Free cutting brass = 100. E—Excellent G—Good F—Fair P—Poor

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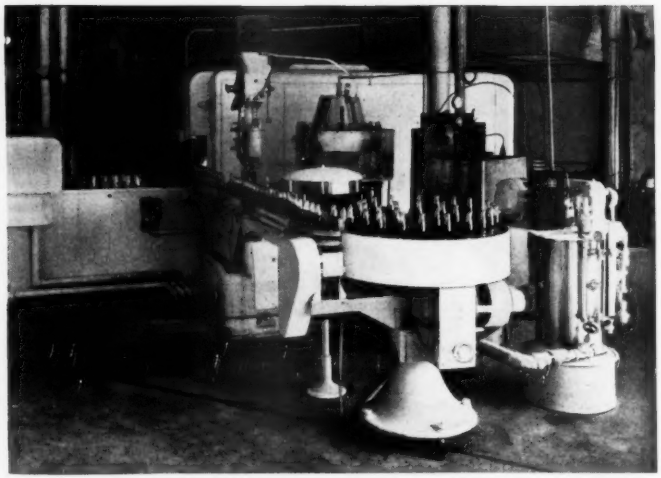

This soft drink bottling machine is a product of The Liquid Carbonic Corporation of Chicago

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Bottles crowd onto an accumulating table at a rapid rate, so a long-wearing, highly polished, stainless steel surface is used there by The Liquid Carbonic Corporation. Liquids spill on that table—another excellent reason for that stainless steel surface; it is corrosion-resistant, as well as wear-resistant.

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Bulletins 255 and 338 describe Lukens Clad Steels. For copies, write Lukens Steel Company, 405 Lukens Building, Coatesville, Pennsylvania.

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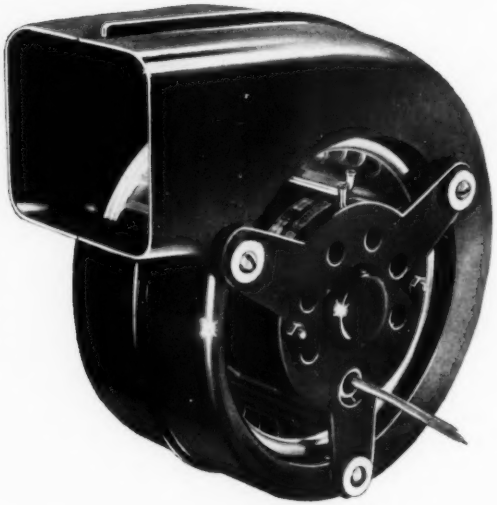

MODEL 3802
This compact motor-in-wheel A.C. blower unit delivers 100 Cubic feet per minute

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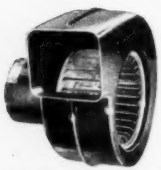
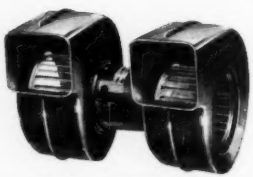


MODEL 3866 A.C.
150 C.F.M.



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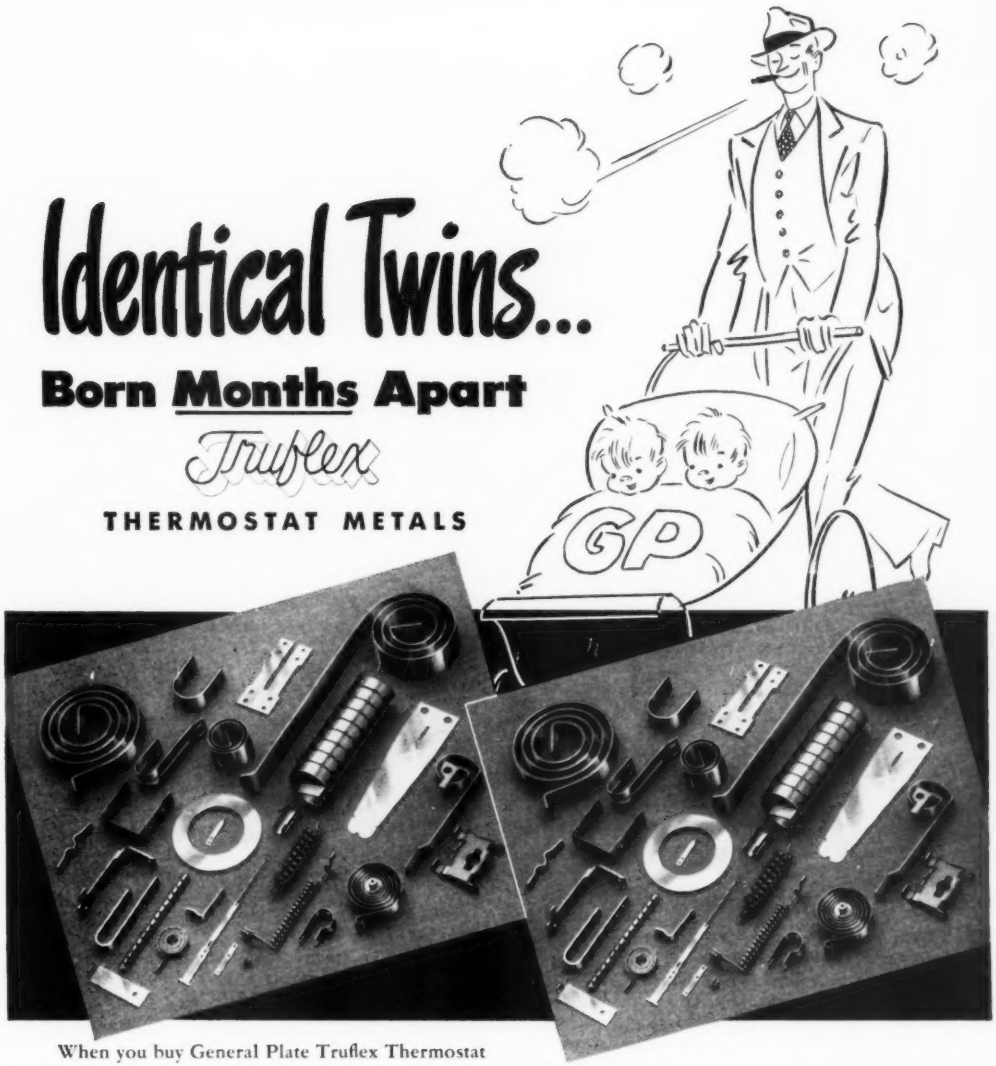

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This dished head-shape needs very little work before it is ready for assembly into the cover for this laundry machine. Zephyr starts right in with the finishing operations; Lukens has already formed the part for them.

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Lukens has many standard head-shapes in stock, ready for shipment. Others can be produced on short notice from our huge stock of dies. We make head-shapes as small as 4 inches and to over 20 feet in diameter; as thick as 6½ inches; from all commercial metals.

3,989 different head-shapes are described in Lukens Catalog No. 1. Stock heads are listed in Bulletin 433. For copies of both, write Lukens Steel Company, 405 Lukens Building, Coatesville, Pennsylvania.

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HEADS

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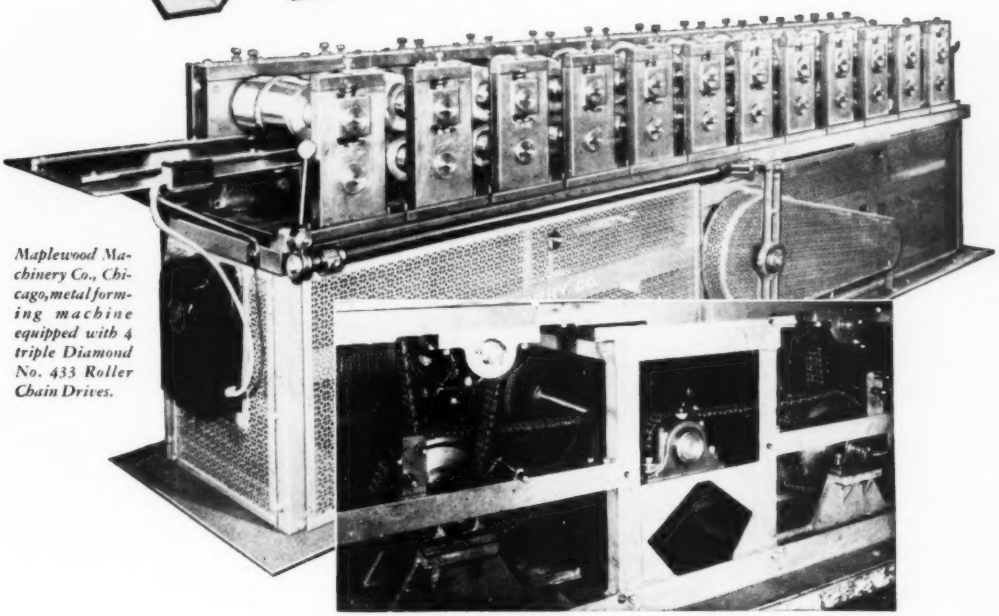
Diamond Roller Chains Speed Metal Fabrication



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● Operating the forming rolls on the high speed Maplewood metal fabricating machines, Diamond Roller Chains provide the non-slipping positive drives required for maximum output.

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"EASY CHAIRS" TO BUILD: Take a look at this handsome living room. How would *you* like to try building furniture like *that*, with wobbly screws and slipping, slashing drivers? Well, neither would the builders of this visibly top-quality line. So they play safe. They use American Phillips Screws *instead of binding the frame together*, . . . and haven't a worry in the world about cost, spoilage, or complications in production. In fact, they guarantee the frame for life.

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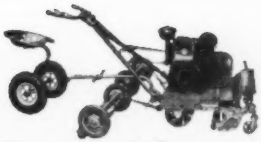
ALL METALS: Steel, Brass, Bronze, Stainless Steel, Aluminum, Monel, Everdur (silicon bronze)

Torrington Needle Bearings Reduce Friction, Simplify Design for Coldwell-Philadelphia Lawn Mowers



Power requirements are reduced by the smooth anti-friction operation of Torrington Needle Bearings in mowers built by Coldwell-Philadelphia Lawn Mower Company. Needle Bearings also provide high radial capacity to take the shock of rough service.

Quick, easy installation of Needle Bearings in mower wheels cuts assembly costs. Only a plain machined bore is required for a housing. No snap rings, shoulders or other retaining devices are needed. These Needle Bearing features mean simplicity and economy.

Lubricant is retained over long periods of service by the close-fitting, turned-in lips of Needle Bearings. In the gang unit cutter clutch gear, above, this construction also helps exclude moisture and dirt. Long service life is secured with minimum maintenance.

A space-saver indeed! A large main clutch shaft is supported in a relatively small housing, thanks to the compactness of Needle Bearings. This construction, plus the tremendous load capacity of these anti-friction units, means a lighter, sturdier mower.

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Cashing in on Progress

CIVILIZATION ADVANCES rapidly during a war period. In such times there are two kinds of progress occurring hand in hand. One is mythical; the other is real. Mythical progress develops first and faster, reaching its peak a few years after the end of the war and then dying in more or less agony. Real progress starts slowly and gradually builds to a continuing high level. It stays with us as a permanent asset, and finally solves the many social and economic problems created by mythical progress.

Mythical progress is in the form of steadily increasing pay envelopes for certain groups. Short supply and long demand bring higher prices and thereby compel higher wages. Wage earners need and receive more money. They feel wealthy in spite of the higher prices. On the face of it, laborers and mechanics seem prosperous when fat wage increases are given them at frequent intervals. But that kind of progress is mythical. The fact that all others must meet increasing prices with little or no increase in income doesn't get much attention.

In the meantime, real progress steadily forges ahead. Scarcity of materials compels better ways of using them. All efforts are made to find faster manufacturing methods, more efficient design and better management in order to combat scarcities of all kinds. The waste of war and the destruction that goes with it challenge the scientist and the engineer to achieve hitherto undreamed of goals. New weapons must be developed, new discoveries must be made to meet war conditions. The minds of men become keyed to a high pitch. The seemingly impossible is achieved.

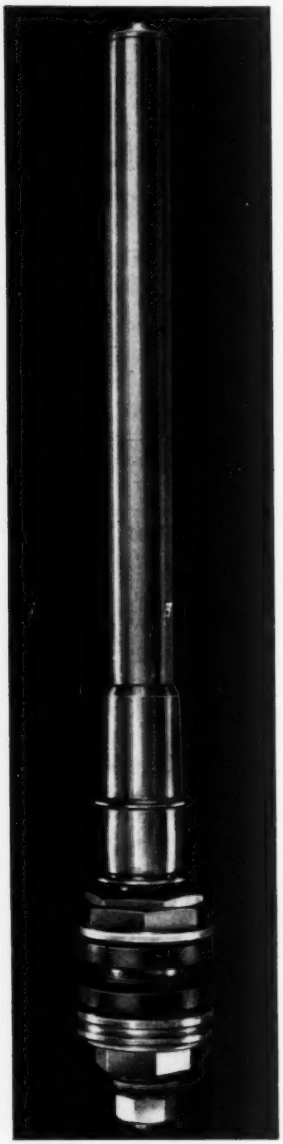
Then comes peace. Gradually the scarcities and shortages of the war period disappear. But the many whose income had not risen appreciably do not have enough money to support the high prices. Surplus commodities then are stored in warehouses. Business faces a depression, recession, or whatever one may care to call it. Plants start shutting down. That is the situation where we are now.

Only by putting to use the real progress made during the war period can a bad economic and social condition be prevented. That means, among other things, the redesign of manufactured products to the end that every possible advantage is taken of the war time developments and progress. If done effectively, designers will use materials more economically, they will call for the most economical production processes to be used and they will apply the best in the newly developed design techniques. The sole objective will be to achieve designs that can be produced at the lowest possible prices. Therein lies the only hope of averting a serious depression.

How much of a drop in prices can be achieved by redesign? That is a question that cannot be answered. Other factors in addition to design will have to contribute to the lowering of costs. But the keystone of any cost reduction program is the design engineer. He is the most important factor in converting real progress into goods and services at prices that can be met by the buying public.

All other things being equal, the degree to which prices can be reduced economically will be the yardstick for the measure of real progress made during war years. Similarly, the degree to which real progress will benefit the public in making better products available at lower prices is primarily up to the design engineers.

AT LAST A MODERN SPINDLE



Designed throughout to promote the most *modern* conditions, the Saco-Lowell New Era Spindle, with New Departure precision ball bearings developed specifically for the purpose, offers a most impressive list of operating advantages.

Spindle blade is stationary and the yarn carrier, supported on two New Departure ball bearings, is the only revolving member.

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Under normal conditions, adjusting, repair or replacement of parts is never required. New Departure ball bearings show no perceptible wear after 30,000 hours' operation.

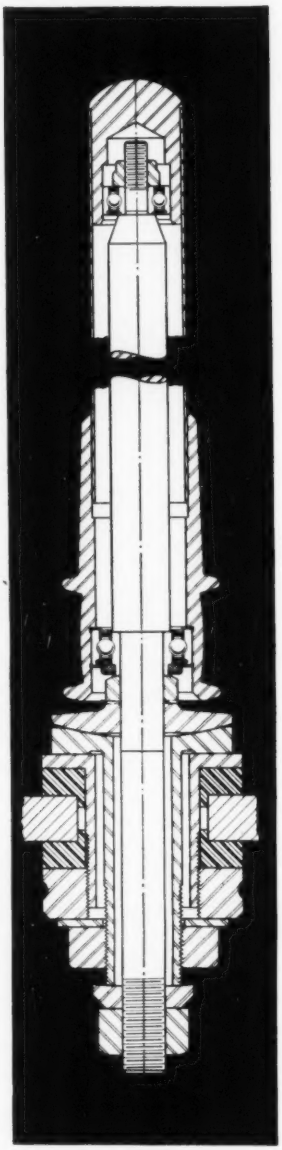
No oil used. Self-enclosed ball bearings are grease lubricated for at least 18,000 to 30,000 hours on a three-shift basis.

New Departure ball bearings provide ample load capacity at high speeds – with no oil throwing – no oil soaked yarn – no oil and lint mixture coating the spindle rail.

Spindle design saves hours of work installing and maintaining accuracy of spindle adjustment.

Performance proved by over five years mill operation and 750,000 spindles before released in unrestricted quantities.

Made for new frames or replacement in old, giving the most *modern* ball bearing advantages in both.



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BALL BEARINGS

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What the New Screw Thread Standard Means to Designers

STANLEY A. TUCKER
Standards Manager, American Society of Mechanical Engineers

INDUSTRY'S DESIRE for rational screw thread tolerances, merged with a 30-year aim for interchangeability of American, British, and Canadian screw threads, has culminated in the new American Standard Unified and American Screw Threads, B1.1-1949.

The new standard makes two valuable gains. First, it gives makers and users of threaded components realistic classes of tolerances that will yield manufacturing economies. Second, it facilitates military cooperation and promotes trade among the three nations by adhering to the Unified Screw Thread System, which is the basis for screw thread interchangeability agreed upon by the three countries November 18, 1948. (Details of this meeting were reported in PRODUCT ENGINEERING, Jan 1949, p 122.)

Six new tolerance classes are established by the standard. Each numerical designation is followed by the letters A or B; A meaning the external thread, B for the internal thread. New thread classes and their applications are:

1. Classes 1A and 1B. The combination of these provides a class of fit for threaded parts where quick and easy assembly is necessary, and where a liberal allowance is required to permit ready assembly even when the threads are slightly bruised or dirty. These classes are intended for Ordnance and certain special uses.

2. Classes 2A and 2B. These classes are well suited for the vast majority of bolts, nuts, and screws and similar on-the-shelf commercial threaded fasteners used in this country. A moderate allowance on Class 2A minimizes galling and seizure in high-cycle wrenching and use. This allowance also reduces variations in bolt stresses when using torque wrenches to get specified tightening torques. Because of this intentional clearance, external threads can be plated, with no resulting difficulties in assembly. Fig. 1(*A*) shows the general character of tolerances, allowances

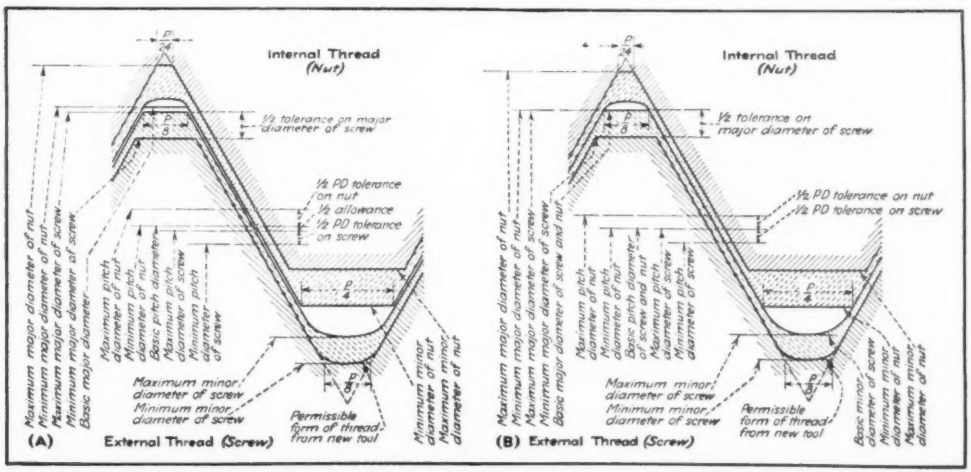

Internal Thread (Nut)
½ tolerance on major diameter of screw
½ PD tolerance on nut
½ allowance
½ PD tolerance on screw
Maximum major diameter of nut
Minimum major diameter of nut
Maximum major diameter of screw
Minimum major diameter of screw
Basic major diameter
Maximum pitch diameter of nut
Minimum pitch diameter of nut
Basic pitch diameter
Maximum pitch diameter of screw
Minimum pitch diameter of screw
Maximum minor diameter of screw
Minimum minor diameter of screw
Permissible form of thread from new tool
Minimum minor diameter of nut
Maximum minor diameter of nut
(A) External Thread (Screw)
Internal Thread (Nut)
½ tolerance on major diameter of screw
½ PD tolerance on nut
½ PD tolerance on screw
Maximum major diameter of nut
Minimum major diameter of nut
Maximum major diameter of screw
Minimum major diameter of screw and nut
Maximum pitch diameter of nut
Minimum pitch diameter of nut
Basic pitch diameter of screw and nut
Maximum pitch diameter of screw
Minimum pitch diameter of screw
Maximum minor diameter of screw
Minimum minor diameter of screw
Permissible form of thread from new tool
Basic minor diameter of screw
Minimum minor diameter of nut
Maximum minor diameter of nut
(B) External Thread (Screw)

Fig. 1—(A) Disposition of tolerances, allowances, and crest clearances for Classes 1A, 1B, 2A, and 2B. The root and crest shapes accommodate the British rounded form. The allowance specified assures easy assembly of mating threads. (B) New Classes 3A and 3B are for high accuracy threads. They provide no allowance, but in practice assure a slight clearance.

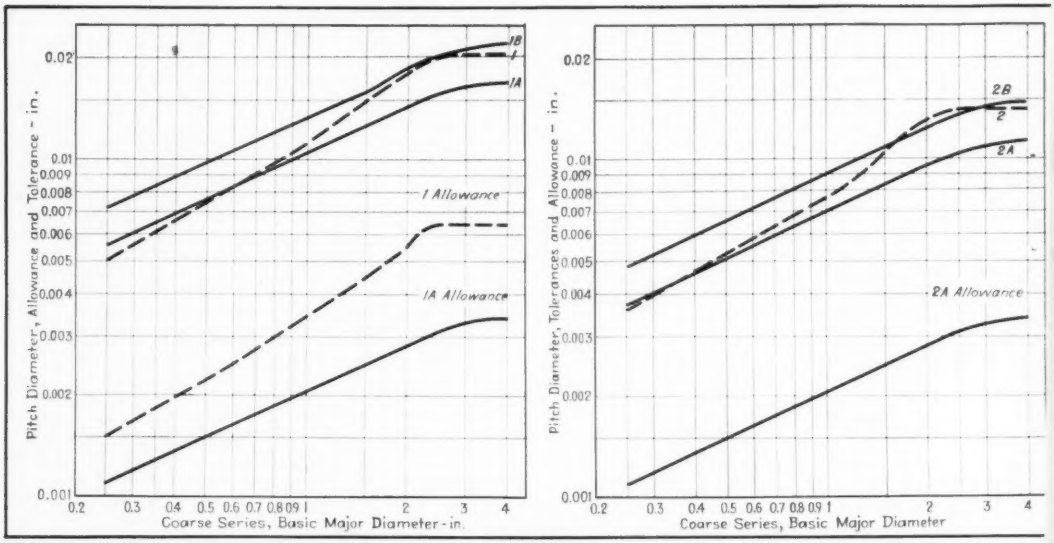


Fig. 2—Comparison of new tolerances and allowances of the coarse thread series with those of the old standard. Note the new allowance for Class 2A. Essential difference between old Class 2 and new Classes 2A and 2B is that the total maximum error has been redivided to: (1) provide a positive allowance on the screw; and (2) allow a 30 percent larger share of the

and crest clearances for Classes 1A, 1B, 2A, and 2B.

3. Classes 3A and 3B. The combination provides a class of fit for applications where closeness of fit and accuracy of lead and angle of thread are essential. Consistent production of these threads requires high accuracy production equipment, supported by efficient inspection. Although no allowance is provided, tolerances on "go" gages are within limits of product size. Thus, the gages assure a slight clearance between mating threads made to maximum limits. The illustration in Fig. 1(*B*) shows the character of fit obtained by combining Classes 3A and 3B.

How The Classes Were Established

All of these new tolerance classes stem from the Class A formulation, growing out of industry's desire to develop an external thread with an allowance. Such a class, it was hoped, would prevent chance interferences by providing clearance between maximum size screw and minimum size nut permitted by the former tolerances.

This goal is realized in the new standard. Both Classes 1A and 2A are provided with allowances, as can be seen in Fig. 1(*A*). As an additional aid to simplification, the new tolerance classes are all derived from the formula for Class 2A:

$$\text{Tolerance} = 0.0015\sqrt[3]{D} + 0.0015\sqrt{L_e} + 0.015\sqrt[1.5]{p}$$

Where: D = basic major diameter, in.
L_e = length of engagement, in.
p = pitch, in.

From this pitch-diameter tolerance formula for 2A, the tolerances and allowances for the other classes can be determined. Table I shows these relationships, giving the tolerances and allowances as a percentage of Class 2A pitch diameter tolerance.

The new Standard includes these tolerance classes in the Coarse and Fine Series. They are designated UNC and UNF, meaning American Standard Unified Coarse and American Standard Unified Fine, respectively. The UNC and UNF designations hold only for threads $\frac{1}{4}$ to 4 in. in diameter in the Coarse Series, and $\frac{1}{4}$ to $1\frac{1}{2}$ in. in the Fine Series. All other classes will retain the designation of NC, NF, and NEF—American Standard National Coarse, National Fine, and National Extra Fine, respectively.

Thus, in specifying the new tolerance classes on drawings, the designer need simply change the designation from say "$\frac{3}{4}$—10 NC—2" to "$\frac{3}{4}$—10 UNC—2A", or from "$\frac{1}{4}$—28 NF—2" to "$\frac{1}{4}$—28 UNF—2A".

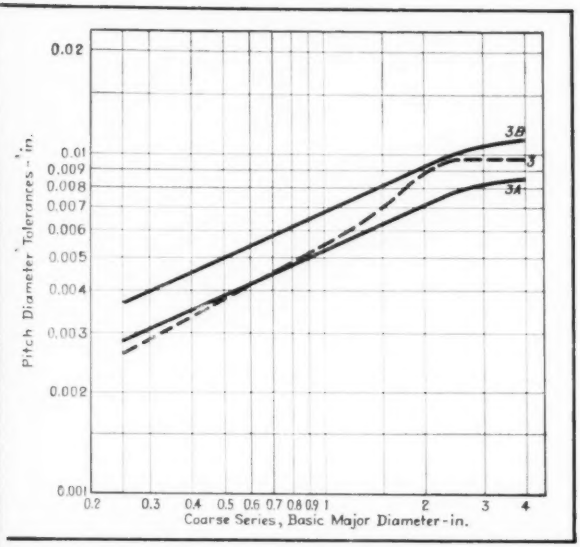
Advantages of the new tolerance classes over the old ones become apparent when comparing the two.

First, the new classes are more rational. As will be noted from the formula, they are based on diameter, pitch, and length of engagement. The old Classes 1, 2, and 3 were based on pitch alone. The new tolerance formula has been weighted for each of the three factors—diameter, pitch, and length of engagement—based on accumulated shop experience.

A case in point is the pitch-diameter tolerances for 7/16—14 UNC—2A, and $\frac{7}{8}$—14 UNF—2A; they are 0.0047 in. and 0.0054 in. respectively. These tolerances

Table I—Relationship Between Pitch-Diameter Tolerances and Allowances of New Classes in Terms of Class 2A Tolerance

Thread Class Designation	Pitch-Diameter Tolerance, Percent	Pitch-Diameter Allowance, Percent
1A	150	30
1B	195	
2A	100	30
2B	130	
3A	75	
3B	97.5	



remaining permissible error to the tapped hole. These charts also show the difference in clearance for various diameters when old and new class threaded parts are mated.

are more reasonable than that of 0.0049 in., which was specified for both diameter-pitch combinations in the old Class 2 for the American National Coarse Series.

Obviously, the new tolerance classes are more rational from a production standpoint. It is reasonable to expect, and to allow, greater tolerances for a larger diameter than a smaller one. Arbitrarily establishing a fixed tolerance regardless of diameter, as with the old tolerance classes, increased production cost unreasonably for many sizes. Thread users who refused to suffer such a cost differential had to deviate from the old American Standard and specify special threads.

Another shortcoming of the old tolerance classes is their lack of compatibility with thread manufacturing characteristics. Specified tolerances for fine pitches were too low, thus shortening tool life. Yet for the coarser pitches the old tolerance formula gave too high a tolerance. Shop experience has revealed the production characteristics of thread-forming tools for rolling, cutting, and grinding, and has given a basis for new tolerance classes which remedy shortcomings of the old ones. Rational nature of the new classes is illustrated by Figs. 2 and 3, which picture graphically the differences between old and new class tolerances and allowances.

Changing From Old to New Standard Threads

No transition difficulties from the old classes to the new are anticipated. The designer is free to use practically any combination of thread classes, new and old, that suit his needs.

One big reason for this is that the Unified Screw Threads gave rise to a new concept of thread class. "Class" formerly had been misconstrued as "fit;" the implication being that both components should have the same class tolerances. For instance: the idea that a Class 2 internal must be used with Class 2 external, and Class 3 internal with Class 3 external. In the Unified Screw Threads, class signifies tolerance, or tolerance and allowance. Fit is determined by the selected combination of classes for internal and external threads of mating parts.

Examination of Fig. 4 discloses that old Class 1 can be replaced by the combination of 1A and 1B for most practical purposes; the old Class 2, by 2A with 2B; and old Class 3, by 3A with 3B. To ease the transition, old Classes 2 and 3, which are widely used, are temporarily being retained in the new standard. And although old Class 1

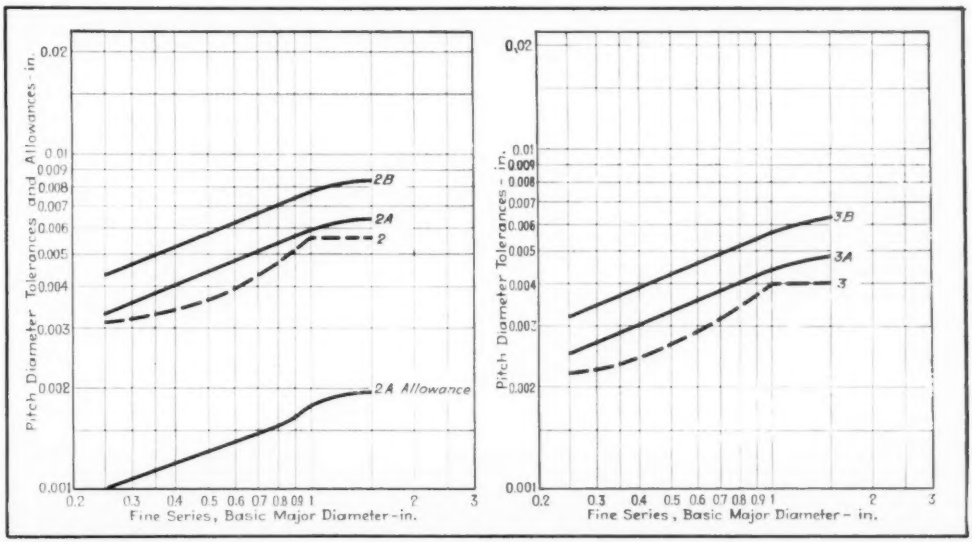


Fig. 3—New tolerances and allowances for the fine thread series compared with those of the previous thread standard.

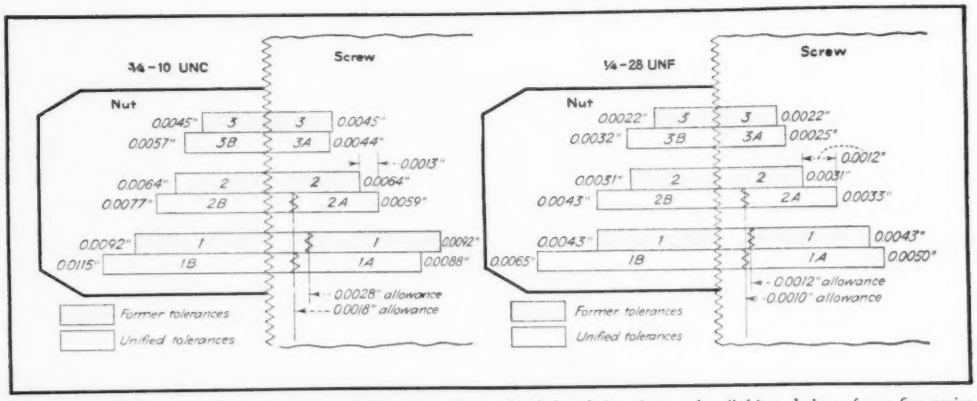


Fig. 4—This schematic diagram compares pitch-diameter tolerances and allowances for a coarse series ¼-in.-10 thread of the Unified and American series (left) and those for a fine series ¼-in.-28 thread of the new and old classes (right).

is obsolete, it is given in an appendix to the standard for information.

Major automobile and airplane manufacturers already have indicated their intentions to switch from the old classes to the new ones, and to change their drawings accordingly, except in special cases.

The new concept of fits—selecting proper combinations of thread classes for specific applications—is further exemplified by the way various combinations can be obtained with the new Classes. For instance, Class 2A (external thread) can be mated with Class 1B, 2B, or 3B (internal thread). By the same token, a Class 3B internal thread can be combined with Class 1A, 2A, or 3A external thread. The relationship between the new thread classes, as shown in Table I, makes this possible.

Because the new classes are more rational and permit a greater variety of fits by combination of tolerance classes, users of threaded parts will be able to find, more easily, the kind of fits they want from the standard classes. By finding what they want in the standard, rather than ordering special threads to satisfy their needs, manufacturers will be able to secure threaded fasteners more economically.

The advantages the designer will gain by using the new American Standard tolerance classes include:

1. Speedier assembly because of an allowance, eliminating trouble in high-cycle wrenching that occurs with chance combination of maximum screw and minimum nut.

2. Freedom to plate threaded parts (except those in Classes 3A and 3B) and thus extend their life by preventing corrosion.

3. Interchangeability of new classes with old ones.

Modifications for Interchangeability

The new tolerance classes as well as other aspects of the new American Standard for Screw Threads reflect the American-British-Canadian accord on screw thread interchangeability; the tolerance classes have been accepted as the basis for their tolerances by Britain and Canada. Those marked UNC and UNF are common to three countries. Other factors which make possible interchangeability are thread angle, thread form, and pitch.

Major obstacle to British and American screw thread interchangeability was the thread angle. Since 1845, the British have used the 55-deg angle Whitworth thread with rounded crests and roots. The American system, developed by Sellers in 1864, has a thread angle of 60-deg and a thread form with flat crests and roots. The new accord establishes a 60-deg angle for common, straight threads used in the three countries.

Differences in the root and crest shape phase of thread profile have been reconciled so that interchangeability of both British and American threads is assured, yet no change in thread-making practice of either country need be made. This is achieved because, as shown in Fig. 1(*A*) and (*B*), the Unified Screw Thread permits either a flat or rounded root for the internal thread and specifies a rounded root for the external thread. There is provision for a flat root, such as is produced with a new or unworn tool, for the external thread. Also shown in Fig. 1(*A*) is the flat crest for the internal thread and a flat or rounded crest for the external one.

The British prefer the rounded form because they feel it prevents failures due to high stress concentrations. American designers favor the flat form because (1) tooling is less costly than for the round, and (2) stress considerations are unimportant in a great many screw thread uses. The new American System permits interchangeability despite the fact that Americans will continue using flat and truncated crests and roots while the British will continue using the rounded form.

Less difference actually exists between a flat and round crest or root than the casual observer thinks. Although new tooling may cut or grind a flat on the first few pieces produced, sharp corners soon wear or break off so that most threads made by the tool are rounded. Of course rolled threads, by the nature of the process, are rounded.

Maximum metal limits have been set in the new standard so that the usual British rounded root and crest are permissible. The normal, one-eighth of pitch, truncated crest of external threads, lies within tolerances. And the provision permitting tool wear to the approximate contour of existing British practice is favorable to thread rolling, which forms the root by displacing the metal instead of removing it.

Last factor required in the new standard for interchangeability is pitch. Unification of the coarse thread series has been completed by adoption of the ¼-in. size with 12 threads per in., as in the British Whitworth system. But the ¼-in. 13-thread has been retained as an American Standard. This gives the designer a choice of either ¼—12 UNC or ¼—13 NC. The fine thread series has been unified by changing the pitch of the former American Standard 1-in.—14-thread to 12 threads per in. The British changed from 10 to 12 threads in the fine series. Designers desiring

to continue using the 1-in.—14 thread will find it under Special Threads in the new standard. Fine thread sizes below ¼ in., those from 0.060 to 0.216 in., continue to be listed as NF threads; unification of them is still under consideration. Another new item added to the standard is the extra-fine pitch thread series.

When the revised gaging standard now being prepared is completed, gage markings for the Unified Series will be identical to four places in the United States, Britain, and Canada. Not only does this assure interchangeability, but it provides exact dimensional agreement for both military and civilian products. This will go far toward facilitating replacement and repair of Anglo-American equipment.

The designer will find the new standard set up especially to facilitate its use. Key to this simplified usage is the four-group division of tabulated data and formulas for computing size limits. Method recommended for spotting the desired information from the standard is for the designer to try to use a thread listed in the first group, if possible. Should none of these fill his need, he then should proceed to the second group, next to the third group, and lastly to the fourth. Purpose of this recommended method is twofold: (1) to minimize computations and (2) to promote industrywide uniform practice.

To see how the designer would proceed in his selection job, consider a ½-in. screw thread as an example.

In the first group he will find the coarse (UNC and NC), fine, (UNF and NF), and 8-pitch series. However, in the ½-in. size, he will find only three regular threads (½—12 UNC, ½—13 NC and ½—20 UNF) since the 8-pitch series does not extend below the 1-in. size. For this reason, if a 1¼-in. thread were under consideration, the designer could choose among the 1¼—7 UNC, the 1¼—8 N, and the 1¼—12 UNF.

But suppose he doesn't find what he wants in the first group and goes to the second. Here the designer will find tables of selected pitch-diameter combinations in which several pitches are given for each diameter listed. Tolerances are based on a 9-pitch maximum length of engagement. Taking the ½-in. thread example, he will discover six pitches not listed in the first group—14, 16, 20, 24, 28, and 32 threads per in. Since the coarse 12-pitch and the fine 20-pitch in the first group do not give him what his job calls for, his next step is to determine if one of these selected combinations is satisfactory.

If the requirement is still more specialized, so that it cannot be satisfied by the second data group, the designer must resort to the third group. Assume the case on hand calls for these specifications: a nominal diameter of 0.50, 36 threads per in., Classes 2A and 2B, and an 18-pitch length of engagement. The second group contains no data for such a thread.

But he can go to so-called Step Tables in the third group which will furnish him with information for this special thread. Here he will find that: pitch-diameter allowance for Class 2A is 0.0010 in.; pitch-diameter tolerances for Classes 2A and 2B are 0.0033 and 0.0043 in., respectively. These data, together with formulas in the appendix of the standard are all the designer needs for computing limits of size.

In the event that the designer runs into a particularly unusual case—say a ½—80-pitch thread, he will not find pitch tolerances or diameters tabulated in the new standard. Finest ½-in. thread in the thread group is 72 threads per in. In this event, he must use formulas to compute the limits of size for the particular thread class.

Another new item featured in the new screw thread standard is the listing of stress area for the various threads. This gives the designer the assumed area of an externally-threaded part for computing tensile strength. It will be especially helpful in design applications where stress considerations are important. For threads not in the regular series, stress area can be calculated from a formula based on the diameter midway between the mean pitch diameter and the mean minor diameter of a Class 3 thread. The formula is:

$$A_s = 3.1416\left(\frac{E_m + K_m}{4}\right)^2$$

Where: A_s = Stress area, sq. in.
E_m = Mean pitch diameter, Class 3 tolerances, in.
K_m = Mean minor diameter, Class 3 tolerances, in.

Stress area values, as well as the other new features of the American Standard B1.1-1949 previously described, were developed as a revision of the old standard adopted in 1935. The American Society of Mechanical Engineers and the Society of Automotive Engineers jointly sponsor the ASA Sectional Committee B1.

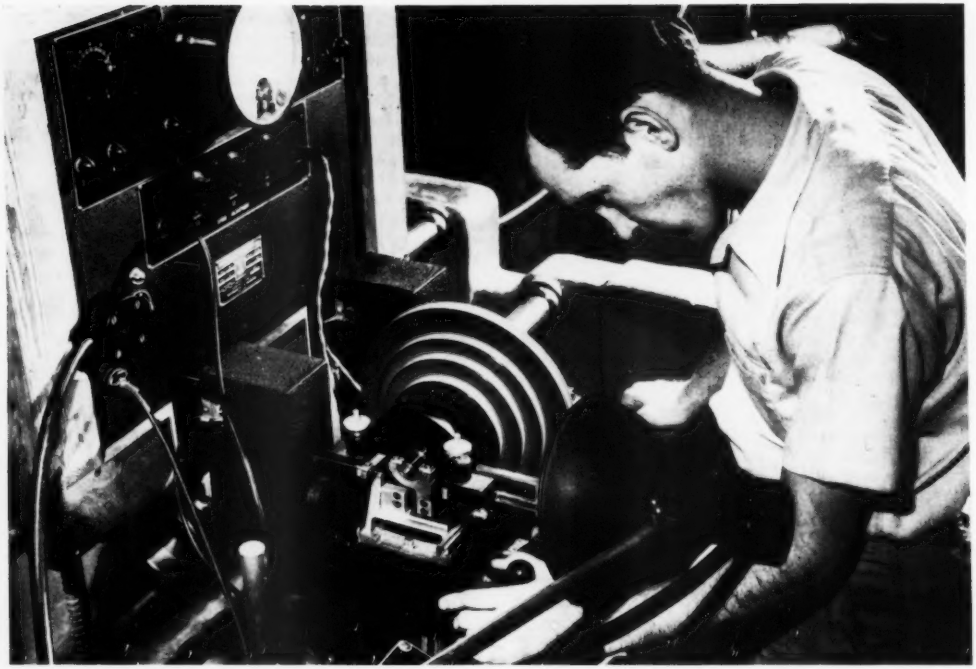
About that June number . . .

HERE ARE A FEW of the design tricks leading to lower product cost which will be included:

- How to cut the cost of a control cabinet by making it larger.
- How a few dollars more for a clutch can save more than twice that amount on the motor.
- How the use of two motors instead of one can cut the total motor cost.
- How to pay more per V-belt yet less per V-belt drive.
- How higher cost parts and materials can give a lower cost, higher quality product.

AND MANY OTHER valuable tips will be in the June number on

DESIGNING FOR LOWER COST



DYNAMIC BALANCING of rotating parts is accomplished in this machine, by addition of proper weight at the located point.

Thermosetting Plastic Laminates—III

Proper application of thermosetting plastic laminates depends on available shapes and fabricating methods. Properties of special shapes vary somewhat from ordinary sheet materials.

NORMAN A. SKOW
Director of Research, Synthane Corporation

CHOICE of a thermosetting plastic laminate for a particular part or product depends not only on the set of property conditions to be fulfilled (see Part II of this series, February PRODUCT ENGINEERING, pp. 138 to 145), but also on the shapes in which these materials are available and the fabricating methods that can be applied to achieve the final form.

Properties of the standard grades of laminate sheets were given in Part I (December 1948, p. 126). However, there are many applications where combinations of base materials can be used to advantage. In radio tube sockets, one layer of Grade C (cloth-base) is placed on the bottom of a paper-base laminate, where the stress is greatest. Bobbin heads for spools used in the textile industry are often made of a combination of Grades C and XX; the outside half of the spool head is made from Grade C to reduce breakage in rough handling, and the inside is made from Grade XX to provide a smooth take-off surface for fine filament yarns, preventing snagging and breakage of filaments.

Another useful combination is a "sandwich" of rubber or neoprene with laminate sheets, where the properties of both materials are required. Such combinations are usually applied with rubber on one side of the laminate sheet; rubber or laminates on both sides with the other material between; or alternate layers of both materials. An example of such a combination is a seal washer used on the electrical terminals of electrolytic condensers placed in metal containers. The can is crimped over the rubber to make a tight joint, the rubber seals the container against leakage, and the laminate adds needed strength to the combination.

Choice of Shapes

In addition to laminates in sheet form, tubes, rods and special molded shapes should be considered in design. On a weight basis, sheets are usually cheaper than rods or tubes, and are more economical to use where practical. For example, disks and washers are cut from sheet rather than from more expensive rods and tubes. However, shapes other than sheets have special advantages in many applications.

TUBING. In manufacturing thermosetting plastic tubing, layers of impregnated paper or fabric are wound under heat and pressure on a mandrel corresponding to the inside tube diameter required. Rolled tubes are oven-cured after winding; those cured under heat and pressure are known as molded

tubes. Exact outside diameters are obtained by grinding. If desired, they can also be sanded and polished.

The choice between using rolled or molded tubes depends on several factors. Paper based rolled tubes generally have better dielectric strength, power factor and dielectric constant. Molded tubes usually have a lower percentage of moisture absorption. Where concentricity of outside and inside diameters is important, rolled tubes are generally recommended.

Rolled and molded tubing are supplied in the following grades (properties given in Table V):

X—For general use where high mechanical strength with good punching and machining qualities are required. Good electrical properties under normal atmospheric conditions.

XX—For low moisture absorption, low power factor and low surface leakage. Machines readily and has minimum cold flow. Rolled tubes are preferred for punching.

C—Good mechanical properties. High compressive and impact strength. Punches and machines easily.

CE—Good mechanical and machining properties. Recommended in place of Grade C where good electrical properties are required.

L—Good mechanical properties. Fine weave fabric base gives it unusually easy machining qualities, particularly for fine threading and punching operations.

LE—Good mechanical and moisture resisting properties. Excellent machining qualities. Good electrical properties. Molded tubing recommended for electrical applications under humid conditions.

A—Denser than paper or fabric base grades, low moisture absorption, heat and flame resistant.

AA—Properties similar to Grade A, except it machines more readily. Low moisture absorption and good dimensional stability.

Maximum outside diameters of rolled tubing are in the neighborhood of 24 in. Molded tubes can be supplied in outside diameters up to 4 in. only, depending on the availability of the mold. Usual lengths of tubing are 18 and 36 in., but rolled tubing can be supplied in longer lengths. Inside diameters vary from $\frac{1}{8}$ in. to 22 in.; wall thicknesses from 0.0075 to 2.0 in. Usual colors are natural and black. Tubing can also be produced in sections other than round.

Paper base tubes find their widest application in the electrical and radio fields. For power transformers operating in oil or air, Grade X rolled tubes up to 23 in. in OD are used. Grade X tubes are also used for brush holder bushings, because of their resilience. Grade XX tubing is applied in relays, controllers, automatic power switches, and other heavy electrical apparatus. For renewable fuse cases, a special paper base grade that has a flash-proof fiber lining, is used.

Where toughness is important, fabric base tubes are preferred to paper base. In textile applications, Grade C tubing is often used. However, when bobbins and barrels are in contact with delicate fibers, the smooth surface of Grade XX tubing is preferred.

Table V—Properties of Rolled and Molded Tubing*

Grade	X Paper base	XX Paper base	C Fabric base	CE Fabric base	L Fine weave fabric base	LE Fine weave fabric base	A Asbestos paper base	AA Asbestos fabric base
Tensile Strength psi (min)								
Molded	9,000	7,500	7,000	6,500	6,500	6,000	5,000	8,000
Rolled	7,500	7,000	5,500	5,500	5,500	5,000	4,500	6,000
Compressive Strength (axial) psi (min)								
Molded	15,000	15,000	18,000	19,000	18,000	19,000	12,000	18,000
Rolled	10,000	12,000	11,000	12,000	11,000	11,000	10,000	9,500
Density (min) g per cc								
Molded	1.25	1.25	1.25	1.25	1.25	1.25	1.40	1.40
Rolled	1.10	1.10	1.10	1.10	1.10	1.10	1.20	1.20
Dielectric Strength, 0.001 in., volts per mil (min)								
Short Time Test								
Molded	400	300	....	175	....	175	200	50
Rolled	500	400	....	125	....	150	150	40
Step by Step Test								
Molded	250	200	....	110	....	110	125	30
Rolled	300	250	....	90	....	100	100	30
Moisture Absorption (max), percent								
Molded	4.0	2.0	2.2	1.5	1.75	1.10	1.5	1.0
Rolled	5.0	2.5	3.0	2.5	3.0	2.5	2.5	2.0
Power Factor at 10^6 cycles (max)								
Molded	0.045	0.040	....	0.065	....	0.055	....	....
Rolled	0.040	0.040	....	0.055	....	0.045	....	....
Dielectric Constant at 10^6 cycles (max)								
Molded	6.0	5.5	....	5.5	....	5.5	....	....
Rolled	5.0	5.0	....	5.0	....	5.0	....	....

*All tests were made at room temperature, approximately 25 C, following ASTM Method D348-46.
Paper base tubes used in above tests were 1 in. ID x 1½ in. OD.
Fabric base tubes used in above tests were 1 in. ID x 1¼ in. OD.

Table VI—Properties of Molded Rods*

Grade	XX	C	CE	L	LE
Tensile Strength (min) psi (approx ½ to 1 in. dia)	8,500	8,000	7,000	8,000	6,000
Flexural Strength (min) psi (approx ½ to 1 in. dia)	15,000	17,000	14,000	16,000	12,000
Axial Compressive Strength (min) psi (approx ½ to 1 in. dia)	20,000	20,000	21,000	20,000	21,000
Water Absorption, percent ½ in. dia (max)	1.00	2.00	1.00	1.20	0.90

*All tests made at room temperature, 25 C, following ASTM Method D349-42.

RODS. All molded rods are available in ground, buffed or varnished finish. Physical properties are shown in Table VI. Rods can be machined from sheet stock, and when so made their properties generally conform to those of the sheet from which they are cut. All rods are available in natural or black colors. Lengths from 18 to 36 in. in small diameters and 30 to 36

Table VII—Comparison of Standard Grade with Molded-Laminated and Molded-Macerated

(Grade C material used, since it is commonly specified in all three types)

Property	Standard Sample	Value	Sample for Molded-Laminated and Molded-Macerated	Molded-Laminated	Molded-Macerated
24 hr water absorption, percent	3 x 1 x 1/8 in.	1.7	4 in dia 1/8 in. thick	0.50	0.50
Dielectric Strength, short time test volts per mil	1/8 in. thick	325	4 in. dia 1/8 in. thick	325	260
Tensile Strength, psi	ASMT test sample	9,500	special shape	9,000	7,800
Flexural Strength, psi	1/2 x 1/2 x 5 in.	20,000	1/2 x 1/2 x 5 in.	20,000	12,000
Compressive Strength (flatwise) psi	1/2 x 1/2 x 1/2 in.	38,000	1/2 x 1/2 x 1/2 in.	38,000	27,000
Izod Impact Strength ft-lb per in. notch width (flatwise)	Notched bar 1/2 x 1/2 x 2 1/2 in.	3.2 (min)	notched molded bar, 1/2 x 1/2 x 2 1/2 in.	3.2 (min)	2.0
Specific Gravity	1 x 1 x 1/8 in.	1.36	1 x 1 x 1/8 in.	1.36	1.36
Rockwell Hardness	1 x 1 x 1/8 in.	M105-M110	1 x 1 x 1/8 in.	M105-M110	M105-M110

in. in large diameters are available. Paper base rods are available in minimum diameters of 1/8 in. up to 1 3/4 in.; fabric base in minimum diameters of 3/16 in. up to 4 in. Where larger diameters than these are required, it is recommended that the rod be turned from sheet stock. Maximum diameter of Grade A is limited to 1 3/4 in. and that of Grade AA to 4 in.

MOLDED-LAMINATED. Before curing, laminations are cut from the impregnated base materials to fit a given size mold. This construction is more desirable and economical than standard shapes where the quantities involved are sufficient to warrant the cost of molds over the cost of extensive and intricate machining.

Many molded laminates are simple in curvature and shape, with a minimum of draw; thus, the molding make-up is simply a number of sheets, of a definite weight, cut to a slightly larger size than the finished molding. Several types of refrigerator inner doors are produced by this method. Completion of these moldings is performed by sawing or clipping to size, punching or drilling of holes and finishing of the edge.

Molding make-ups sometimes consist of coils of materials wound to a specified inside and outside diameter and having a definite weight so that no further processing is necessary. Inserts can be molded in by proper preparation of the coil charge and molding powders can be used to fill in around bosses and heavy sections. Coil charges are used in molding casters, magneto covers, gear blanks, wheels, and various types of equipment and machinery covers.

Die-cut patterns of resin treated fabrics or paper for molded laminates are used in molding gear blanks, covers of various types, arm rests, and many other parts.

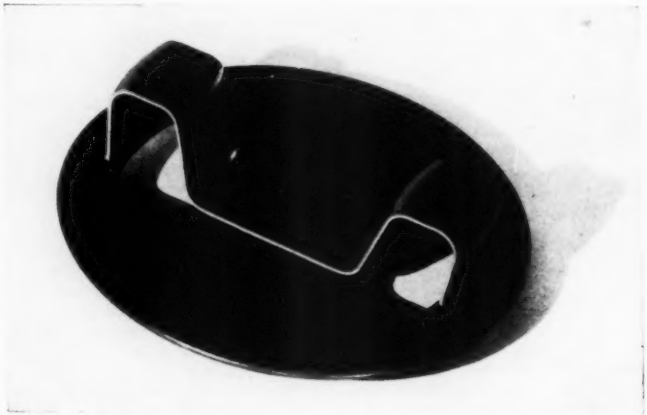
MOLDED-MACERATED. Sometimes a part is more intricate in shape, or of such a design that it is not practical to cut laminations to fit the mold. For such parts the coated fabric is chopped into pieces from 1/8 in. to 1/2 in. square. These pieces or flakes are placed in a mold of the required design and cured under heat and pressure in much the same way as powder molding, except that the cure cycle is much longer, because of the different type of resin.

Macerated materials exhibit from 50 to 75 percent of the mechanical strength of the corresponding laminated or molded-laminated grades. Since they have no "grain", the strength characteristics of molded-macerated are more uniform than those of laminated construction. Variations in strength in different directions that do occur are caused by the effect of the direction of molding pressure upon the lay of the flakes in the mold.

However, with the proper size flake and a well designed mold, this variation is not serious. Mechanical, electrical and physical properties can be varied over a considerable range by changing resin content, cure, and type of filler. Thus, various properties can often be adjusted within limits to suit the needs of the user.

The test figures shown in Table VII should not be considered exact values that cannot be altered by changes in make-up. The same or a greater amount of variation in test values is possible with molded-macerated as with straight laminated grades. For instance, higher tensile and transverse strength values can be had at the expense of impact strength, or better impact strength is possible at the expense of the electrical properties.

The impregnated flakes produced for macerated fabric do not have the flow characteristics of molding powder. Offsets, where the molding pressure is not so great, may be weak or of poor appearance because of insufficient flow of resin. The normal motion of the die is up and down. Side holes or under-



NYLON SIZING bobbin cap has two parts, made of two different materials. Cap is made of Grade XX thin sheet; fastened to it is a Grade C postformed "spring" which holds the cap in place, but allows quick removal or insertion.

cuts can be created at additional mold cost, but because of flow difficulties of this type of material, it is preferable to machine sidewise holes or undercuts. Sidewise pins are to be avoided. The poor flow characteristics of the macerated pieces exert pressures which often fracture sidewise pins. The bulk-factor, which is the ratio of the volume of material in flake form to the final volume in the molded form, may be as high as 4 to 5. Preforms can be made to reduce the bulk factor, and are, in fact, becoming more widely used.

There are many applications for molded-macerated grades, particularly among the suppliers of aviation and Navy equipment accessories.

COMBINED MOLDED-LAMINATED AND MOLDED-MACERATED. Occasionally molded-laminated and molded-macerated techniques are combined in one molding to produce desirable strength characteristics.

Post-Forming

Post-forming is a convenient means of obtaining a shaped piece of laminate without using expensive molds. Although standard Grade L and Grade C phenolformaldehyde laminates can be post-formed to a limited extent at elevated temperatures, special grades permit much deeper draws without tearing. The special grades use a fabric that provides stretch when needed and a resin that will soften on heating, yet can be removed from the forming die while still hot, and provide finished articles of maximum rigidity.

Channel shaped pieces which can be formed by simple bending are the easiest to make. Box or domed shaped pieces require drawing and forming in the same way that sheet metal is deep die drawn.

Four steps are necessary to shape the flat laminate into a finished article: Cutting to shape, heating to a formable condition, shaping and cooling. The cutting procedure depends on the article itself but generally the pieces are sheared, sawed, blanked or routed.

Heating is done in circulating or non-circulating hot air ovens, oil or salt baths, radiant heating ovens or by contact with hot plates. For proper forming the laminate must be heated under closely controlled temperature and time conditions.

Most formed articles can be processed in simple bending dies with hinged movement. More complicated parts require male and female dies and mechanical pressures. Drawing operations require tools similar to those used in drawing metal. A hold-down plate and a positive means of controlling pressure are requisites. Hardwood or laminated plastic dies are satisfactory, except for quantity production. Metal wearing surfaces are recommended for the dies used in quantity production runs. The formed parts can be cooled in the forming die or in a cooling frame.

Post-formed laminates are readily machined by standard fabrication methods. In addition, it is possible to incorporate ribbing. The formed pieces have all the properties of standard laminates, and when correctly engineered are more economical to produce and use than similar parts constructed of metal or molded plastics. Aircraft represent one class of products making increasing use of post-formed laminates. These materials are considerably lighter than aluminum, and help decrease the overall weight of the plane. Their vibration absorption is greater than aluminum, and they do not dent as readily.

Design and Fabrication

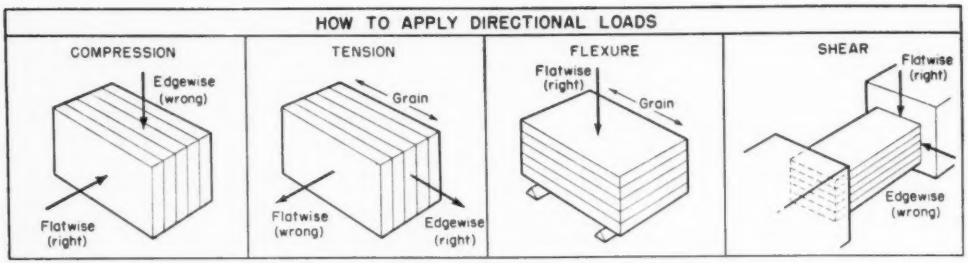
To obtain the best results from thermosetting plastic laminates, consideration should be given to proper direction of loading. In compression, the load should not be applied edgewise (parallel to laminations) but rather flatwise (at right angles to laminations). In tension, it is better to apply load edgewise and with the grain. It should be understood that "grain" refers to the direction of the cloth warp or paper fiber, and is not synonymous with "laminations." In flexure, load should be applied flatwise. Edgewise application tends to cause splitting. Shear resistance is best when load is applied flatwise.

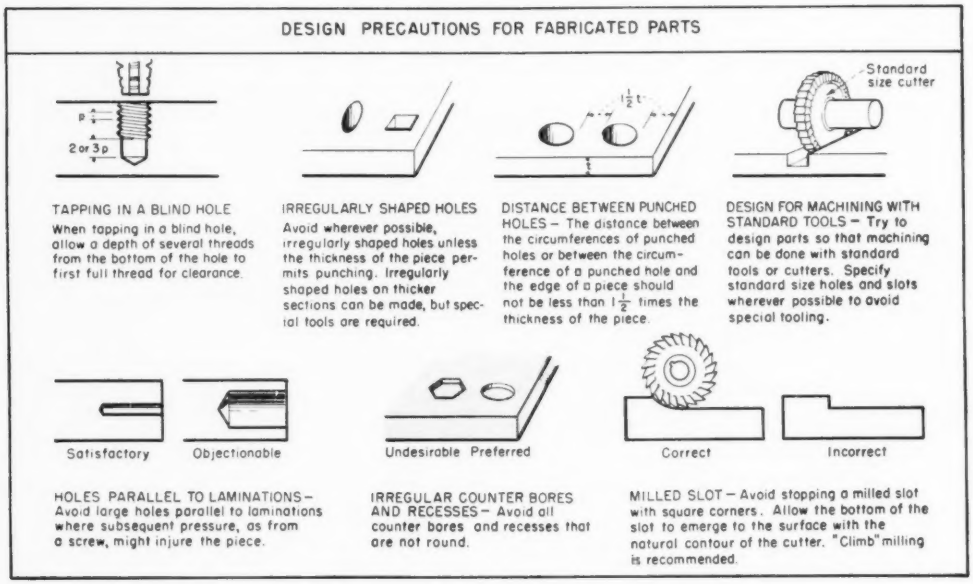
In designing products to be made of molded-laminated and molded-macerated materials, the following rules should be observed: Interior walls, webs, recesses and cavities should have a taper of not less than 1 degree. Taper on outside walls is desirable because it facilitates removal from the mold. Abrupt changes in wall thickness, and undercuts should be avoided. Ample fillets and webs improve strength of the piece, and reduce warpage on large thin sections. Radii on two sides of a piece should be avoided—better on one side only. Inserts should be avoided if a satisfactory assembly can be made without them.

Laminates can be machined with standard wood-or metal-working machinery, although higher spindle speeds

MOLDED-MACERATED instrument case is made of Grade C material. Nonmetallic case holds a sensitive geophysical instrument; it resists moisture and passage of stray currents.

COMBINATION of sheet stock and tubing is used to make this rayon "cake" holder. Flat portions are Grade XX sheet; tubing is paper base phenolic. Springs are Grade L cloth base sheet.




DESIGN PRECAUTIONS FOR FABRICATED PARTS
p
2 or 3p
TAPPING IN A BLIND HOLE
When tapping in a blind hole, allow a depth of several threads from the bottom of the hole to first full thread for clearance.
IRREGULARLY SHAPED HOLES
Avoid wherever possible, irregularly shaped holes unless the thickness of the piece permits punching. Irregularly shaped holes on thicker sections can be made, but special tools are required.
1½ t
DISTANCE BETWEEN PUNCHED HOLES – The distance between the circumferences of punched holes or between the circumference of a punched hole and the edge of a piece should not be less than 1½ times the thickness of the piece.
Standard size cutter
DESIGN FOR MACHINING WITH STANDARD TOOLS – Try to design parts so that machining can be done with standard tools or cutters. Specify standard size holes and slots wherever possible to avoid special tooling.
Satisfactory
Objectionable
HOLES PARALLEL TO LAMINATIONS – Avoid large holes parallel to laminations where subsequent pressure, as from a screw, might injure the piece.
Undesirable
Preferred
IRREGULAR COUNTER BORES AND RECESSES – Avoid all counter bores and recesses that are not round.
Correct
Incorrect
MILLED SLOT – Avoid stopping a milled slot with square corners. Allow the bottom of the slot to emerge to the surface with the natural contour of the cutter. "Climb" milling is recommended.

are desirable for efficient large-scale production. The low shearing strength of laminates permits high cutting speeds and feeds with much less tool pressure than required for metals, and allows the use of lighter and cheaper machine tools. Rapid and accurate fabricating is possible at surface speeds as high as 1,500 fpm for drilling, 4,000 fpm for boring and turning and 13,000 fpm for sawing. Chiefly because of the resiliency of plastic laminates, all cutting tools must be kept extremely sharp, for accuracy and fine finish. A dull tool will allow the material to stretch slightly before being cut, with the stretched portion returning to its original shape. The difference in size is in direct proportion to the thickness and grade of the laminate used, and it is important to compensate for this reduction in diameter.

Because of the low heat transmission of this material, it is necessary to compensate for its natural insulating properties when performing high speed, confined machining operations. Care must be taken that the material and tool are not burned by excessive surface speed. Air or lubricants can be applied which will allow for a higher cutting speed. In confining operations such as deep-hole drilling, the cutting tool should be removed from the work several times during the operation. Whenever practical, carbide-tipped tools should be used.

Where design will permit, all drilling, tapping and broaching should be done at right angles to the laminations. These operations can be performed parallel with the laminations but care must be taken to prevent splitting. If the material is held tightly in a confined jig, fixture or vise, excellent results can be obtained. The laminated structure of the material also requires care when milling at right angles to the laminations, as in the milling of gear teeth. If the material is not backed up with some rigid material, delamination may occur at the point where the cutter runs through the work.

Method of fabrication depends on thickness, grade and desired finish.

CUTTING. Depending on the grade and thickness, laminates can be sheared with a standard metal squaring shear of the guillotine type, or a rotary shear. Thicknesses over $\frac{1}{16}$ in. can be sheared if the material is heated to 280 F. With standard woodworking high-speed band saws, any thickness up to 10 in. can be sawed at speeds up to 8,000 fpm. Band sawing is recommended for all material 2 in. thick and over, and for all irregular cutting of any thickness. Standard high-speed woodworking saw tables are used for circular cutting up to 13,000 fpm. Carbon or high-speed steel blades without set are recommended and thicknesses of material up to 2 in. can be accurately cut.

PUNCHING. Laminates can be readily punched, shaved and broached, de-

pending on thickness and grade of material. Heat is sometimes required prior to the punching operation. Standard power-driven vertical punch presses can be used. The design of the die is practically the same as for metal work, except that little clearance is allowed between the punch and die and the punch and stripper plate. Extremely close tolerances cannot be met because of normal contraction of the material and thermal contraction when punched hot.

Punching produces a relatively smooth edge in thicknesses up to $\frac{1}{16}$ in. For extra smoothness, especially in thicknesses over $\frac{1}{8}$ in., shaving should be specified. Tolerances can be held closer on drilled holes than on punched holes but rarely is the accuracy of a drilled hole necessary if the hole can be punched.

DRILLING. Resilience and heat insulation of the laminate have a noticeable effect in drill press operations. Heat produced by the cutting and rubbing action of drills and countersinks is dissipated slowly. Expansion of the stock caused by heat closes the hole slightly around the drill, resulting in a hole that is sometimes smaller than the size of the drill. Drills designed especially for laminated plastics have been developed; they have wide, highly polished flutes and a special spiral.

Laminates can be successfully threaded on standard equipment, using high-speed steel taps, dies or single-point chasers. If possible, taps should be from 0.002 to 0.005 in. oversize.

Taps should be ground with a negative rake of from 0 to 10 deg. Die chasers used should have a 33 deg chamfer on the lead and a negative rake up to 10 deg. A slight chamfer around the hole of a piece to be tapped, or on the outside diameter of the piece to be externally threaded, is recommended.

SCREW MACHINE AND LATHE OPERATIONS. Most screw machine and turret lathe work is performed dry, but for the deep hole drilling and threading, a coolant is needed. A mixture consisting of 60 percent paraffin oil and 40 percent kerosene oil is recommended.

High-speed steel, carbide, and diamond tipped tools are used for lathe operations and the tools should be ground from 0 to 10 degrees negative rake for threading and forming. Surface speed of lathe operations performed on laminated plastics should be higher than on brass; otherwise the operations performed on the two materials are similar.

All high pressure laminates can be milled with standard high-speed steel milling cutters, but carbide tipped cutters are recommended for longer life, and can run up to 1,000 surface fpm. Milling cutters should be ground with a negative rake of from 0 to 10 deg. The milling operation can be performed on standard metal working milling machines.

Gear cutting can be performed on standard milling gear cutting machines, using high speed or tungsten tools and operating at a speed of up to 400 surface fpm. Feed depends on the finish desired.

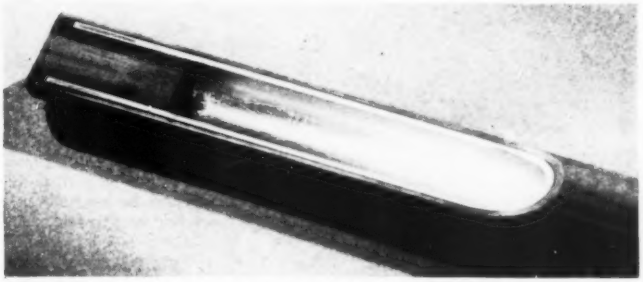
Finishing

Laminates can be engraved, stamped or printed. The engraved impressions are usually filled with a white or colored enamel. Any type of hand or mechanical stamping can be done on laminated plastics with hardened steel stamps. Branding at temperatures ranging up to 500 F can be successfully performed, using sufficient pressure on the hardened steel stamp to obtain the desired depth of brand. Laminates can be printed in various colors on standard printing presses. A coating of protective lacquer is applied over the printed finish to avoid smearing the ink.

Laminates can be sanded on a belt or disk machine or ground to extremely close tolerances. Abrasive belts and disks are operated at speeds up to 200 surface fpm.

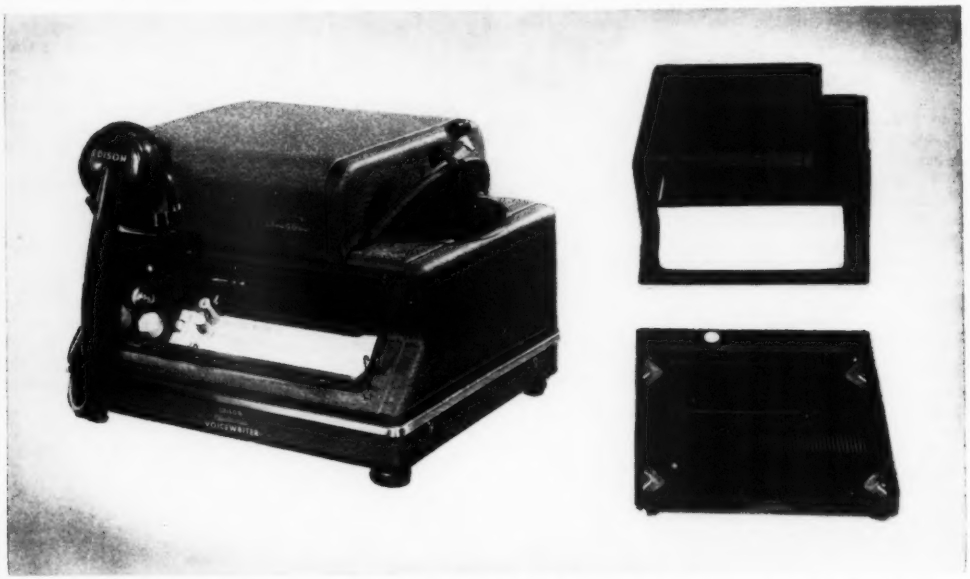
Grinding can be done on standard machines at speeds up to 5,000 surface fpm. A coolant is generally used. The finish desired determines the grain, grade and speed of the wheel.

Molded-laminated and molded-macerated parts are produced in finished or nearly finished forms, requiring little or no machining. Molded and fabricated laminates can be polished by several methods, including tumbling and buffing.



MOIST, hot, sulfurated atmosphere is resisted by these laminated Grade **XX** drier poles. Core of the pole is an aluminum tube for additional resistance to bending; impregnated phenolic paper is wound and cured directly on the metal tube. Smooth surface of the plastic does not snag the yarn.

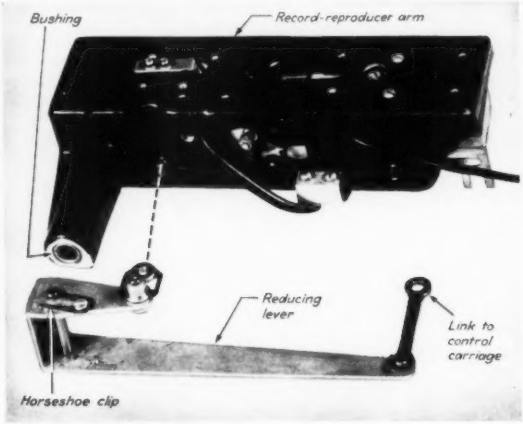
HIGH SPEED precision ball bearing retainers are machined from Grade L tubing. They replace bronze retainers because of lightweight and reduced frictional drag; little or no lubrication is required.



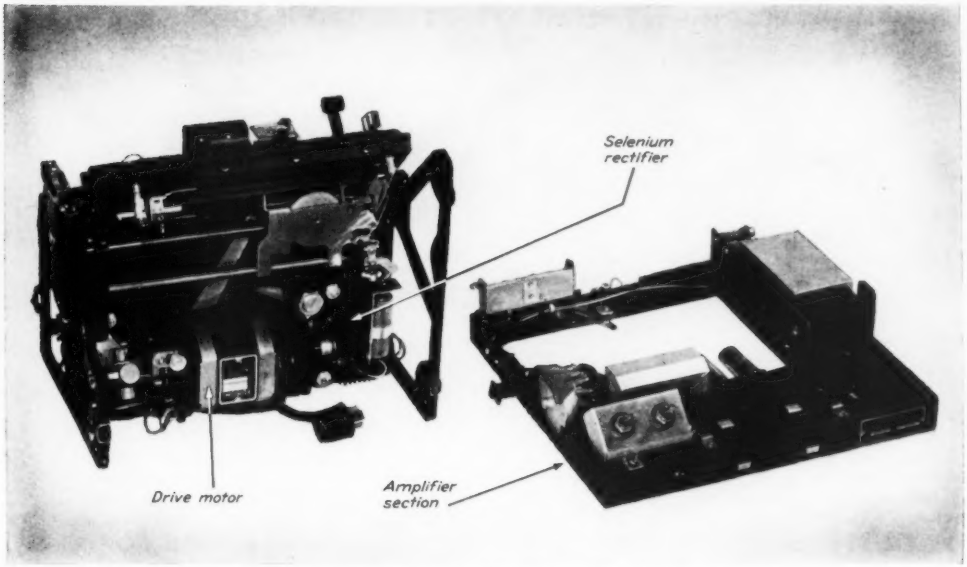
INSTRUMENT RECORDS on a seven in. plastic disk having a 1½ in. center hole. Although a band of only 1½ in. is utilized on each side of disk surface, one disk is sufficient for 30 min of recording. Top and bottom covers are composed of spot welded sheet aluminum. Complete enclosure can be removed without disturbing components which are mounted within frame of die cast aluminum. Louvres in bottom cover admit cooling air.

Dictating Machine Uses Plastic Disk

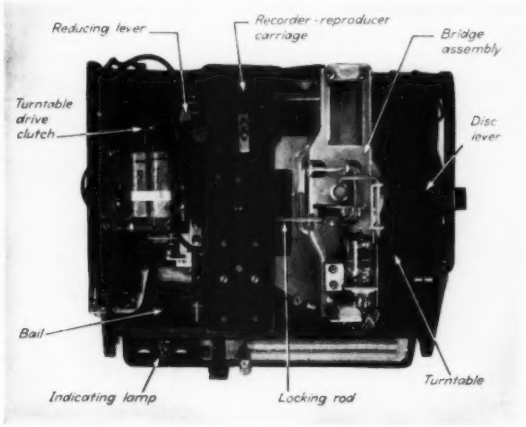
The new plastic disk Voicewriter manufactured by Thomas A. Edison, Inc., West Orange, N. J. features an indexing system whereby lengths of letters, corrections and points of interruption are marked on a card. For accuracy, the 1½ in. band of impressions on the disk is amplified to a length of 5½ in. on the index card. Record positioning is automatic. When the disk receptacle is closed, the record is drawn into place and clamped to the turntable. A lamp on the control panel flashes a warning to user should he attempt to dictate without having a disk in place. Disks can be played back through the dictating microphone, the built-in speaker or an outside speaker. A companion instrument, intended for playback only, is available for use by transcribing departments.



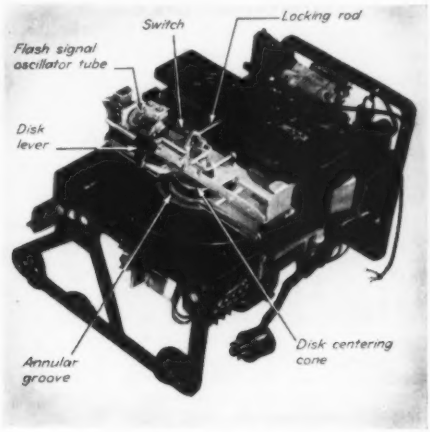
RECORD-REPRODUCE ARM is driven from the control carriage by means of a reducing linkage. Therefore, while full travel of the arm is only 1½ in., the control carriage moves a distance of 5½ in. This feature permits use of an index slip which is long enough to give accurate indication of styli position. The pivot shaft of the reducing lever is supported in a bushing in the topplate of the machine. A horseshoe clip requires the pivot shaft to turn in topplate bushing, not in lever holes.



UNIT CONSTRUCTION of the instrument is illustrated by this view of the amplifier section removed from the bottom of the frame. Similarly, almost all components of the machine are designed as subassemblies easily removed for replacement or repair. Amplifier chassis also acts as structural member of the instrument frame. To make chassis wiring neat and rigid, all small resistors and capacitors are soldered between terminals spaced properly for them.



WHEN DISK LEVER is raised, a locking rod holds the recording and reproducing styli clear of the turntable. Therefore, styli cannot mar disks during replacement. Pushing the disk lever down frees the styli provided a disk is on the table. If no disk is present, however, one end of a feeler mechanism will drop into an annular groove in the turntable. The opposite end of the feeler then supports the locking bar to prevent styli from tearing the rubber surface of the table.



THE TURNTABLE does not have the customary spindle projecting from its upper surface. In place of a spindle a centering cone actuated by the disk lever secures the disk in the recording position. The centering cone is freely mounted on the end of its shaft so that it may rotate with the turntable after clamping.

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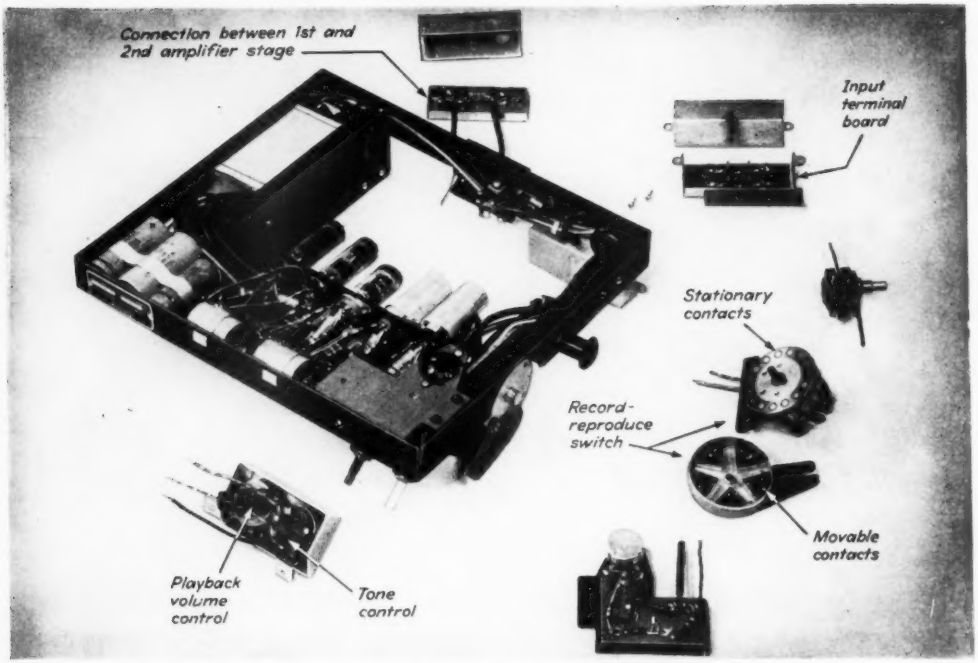
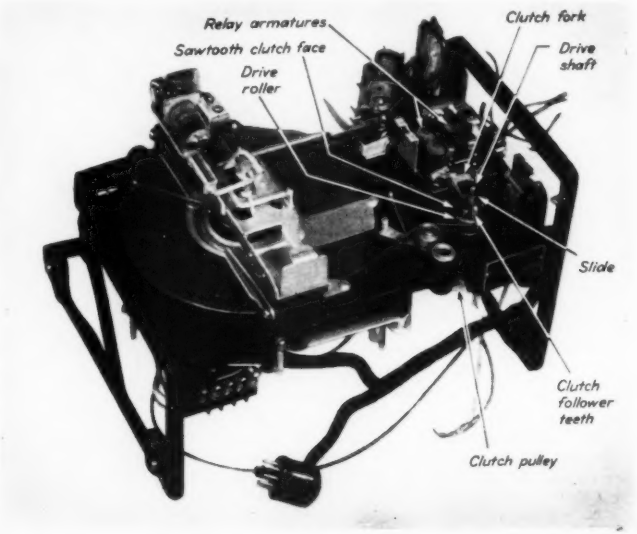
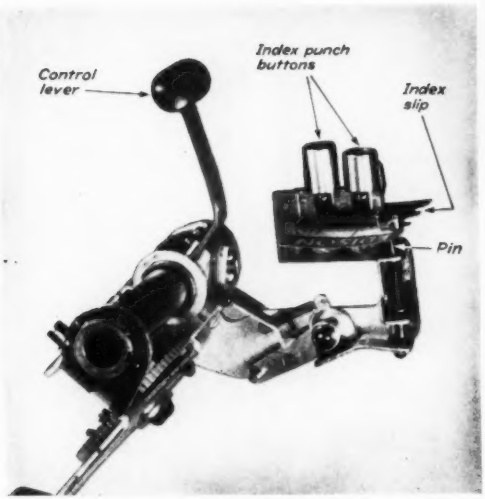


INPUT CIRCUIT between microphone and the grid of the second amplifier stage is completely shielded to eliminate pickup of interference. Parts of the circuit have been grouped about the chassis to show their construction. The critical point of a shielded circuit is usually the selector switch because of the difficulty of isolating one contact from another. This has been overcome in the Edison switch by making stationary contacts flush with switch body. Aluminum separators shield the movable contacts. All heavy elements of the circuit are strapped to the chassis.

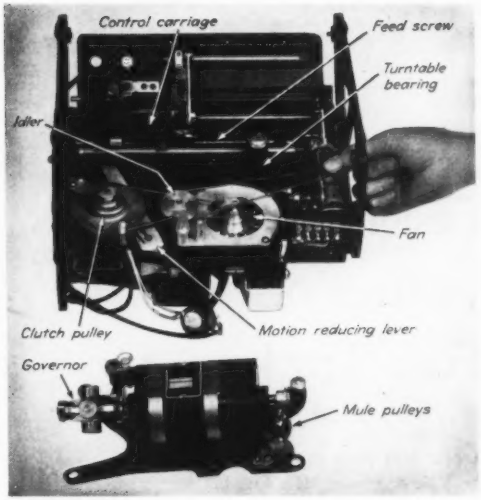
Dictating Machine (continued)

TURNTABLE OPERATION is controlled by a clutch, shown here in the engaged position. Pressing the momentary contact pushbutton in the microphone handle energizes the left-hand pair of coils. The resulting movement of the armatures raises the clutch fork and also throws a switch which breaks the circuit to these coils and connects the second pair of coils to the control button. The fork actuates the clutch slide which is a bushing riding freely on the drive shaft. When the slide drops the follower teeth into engagement with the clutch, the rollers fixed to the rotating shaft will drive the turntable pulley.

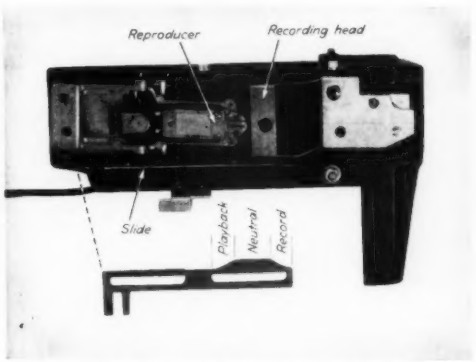




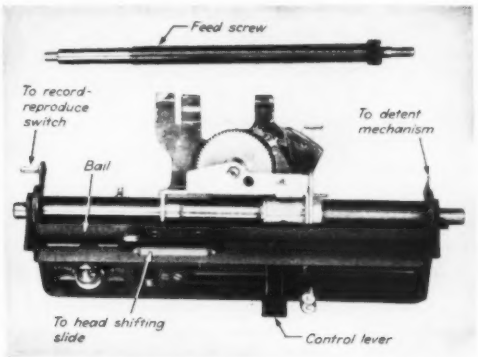
PUNCH BUTTONS which are integral with control carriage are used to indicate ends of letters and corrections on index slip. Each time control lever is moved from recording position, a pin and lever arrangement perforates the index slip. This feature enables the dictator to return the recording head to its exact former position. Operation may be resumed without possibility of cutting into existing impressions or waste of clean disk space. Visible below control lever is the feed lock ratchet. When lever is moved from reproduce to record, two pawls cause ratchet to shift slightly along feed screw. Thus stylus cannot return to last recorded groove and mar it.



CURRENT for the governor-controlled constant speed d-c motor is supplied by a selenium rectifier and capacitive filter. This design permits universal operation of the machine on direct current or alternating current of any frequency without changes in wiring, switching, resistors, etc. As the belt drive is parallel to the motor shaft, two mule pulleys are built onto the motor mounting plate to turn the belt through 90 degrees. Sequence of inter-connected drive is as follows:—motor to fan to clutch pulley to turntable to control carriage to record-reproducer arm. Normal operating speed of the motor is 720 rpm. Speed can be varied to suit speech characteristics of individuals.



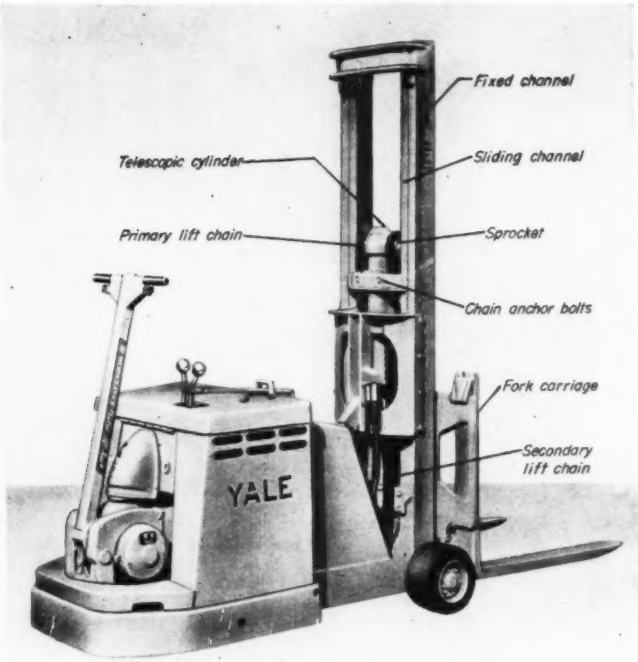
SLOTTED SLIDE controls the positions of the recording and reproducer heads. The hook at one end of the slide engages a short rod mounted on the bail. When the bail is operated, the slide moves into one of the three possible positions—record, neutral and playback. Rollers attached to the recording and reproducer heads ride on the top edge of the slide and are raised or lowered thereby. A centering spring is provided to automatically center the reproducer whenever it is raised from the disk. Thus, reproducer is kept accurately aligned with the index system.



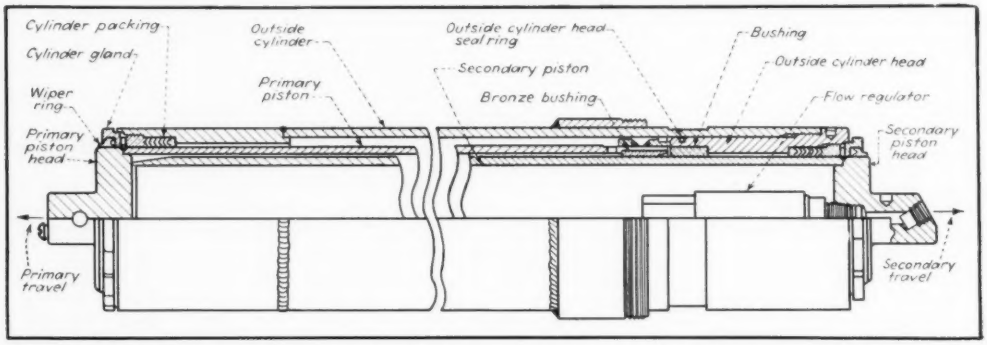
CONTROL CARRIAGE is driven by a long feed screw which is geared to the turntable shaft. The carriage can be shifted to any desired position by means of the control lever. The control lever also operates the bail, a semi-cylindrical aluminum piece which is linked to the selector switch and the recorder-reproducer arm. After the control lever is thrown, the bail position is determined by a detent mechanism. This permits the control lever to move freely in the bail slot and avoids placing any drag on the drive system.

Design Features of Fork Trucks

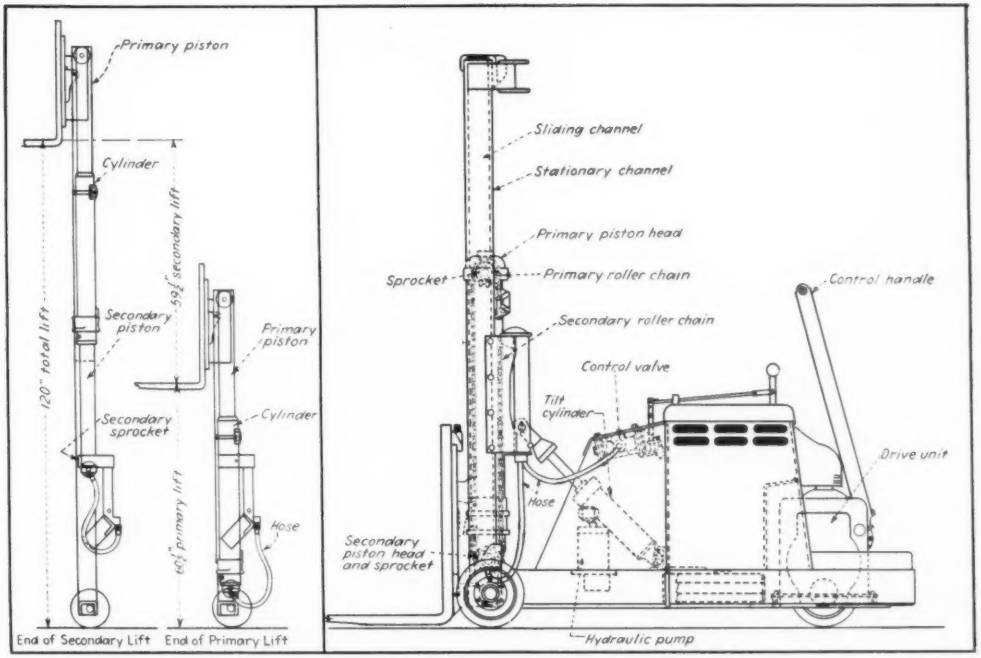
A new fork truck manufactured by the Yale & Towne Mfg. Co., Philadelphia, employs a telescopic hydraulic cylinder to elevate the forks. The cylinder, which contains two pistons in place of the conventional one, has greatly improved the maneuverability of the truck in areas of limited overhead clearance. At no time during a lift does the elevating mechanism project above the truck's channels. Also featured in Yale's line of materials handling equipment are trucks with clamping forks and rotating forks for special applications.

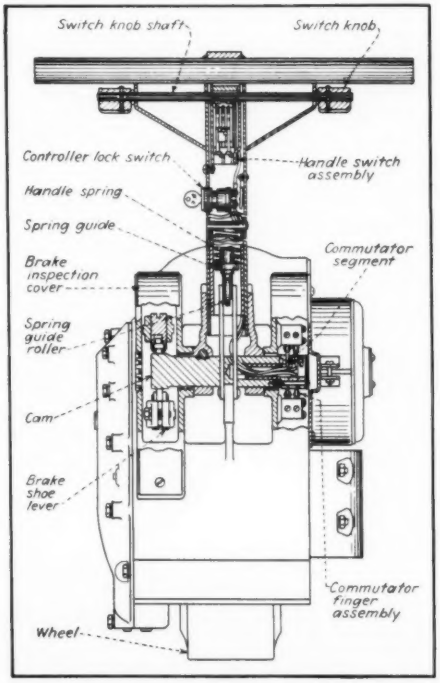


OVERALL HEIGHT of channels in trucks used for freight loading operations is limited to 83 in. for passage through standard freight car door. New telescopic cylinder permits truck to enter car even when fork carriage is elevated to the primary lift position—that is, when top of carriage is level with top of channels. This is not possible where the conventional single cylinder is used since the piston head would project above the 83 in. limit before primary lift is completed. Truck shown is powered by electric storage batteries.



TELESCOPIC HOIST CYLINDER approximately 40 in. long effects total lift of 120 in. Primary and secondary pistons are cylindrical in construction and nest together in the closed position. Although loads on both primary and secondary pistons are about equal, the primary piston only will operate when hydraulic pressure is first applied. The secondary piston will not begin its travel until the primary reaches a mechanical stop which prevents further extension. This sequence of operation occurs because the primary piston has the larger effective area under pressure.





ROLLER CHAINS amplify the movement of the hydraulic pistons. The pair of chains employed in the primary lift are fastened on one end to the fork carriage and on the other, to the sliding channel. When the primary piston moves upward, sprockets fixed to the piston head react against the chains and cause the carriage to rise at a speed twice that of the piston. As soon as the forks reach the end of the primary lift, the secondary piston starts to move downward. However, the secondary roller chains which are anchored between the stationary and sliding channels prevent such movement. Instead, the hydraulic cylinder is pushed upward. Since the cylinder is mounted on the sliding channel, the channel will rise also. As in the case of the primary lift, roller chains again contribute to the elevation of the forks. The secondary chains, moving upward with the sliding channel, pull the secondary piston head along with them. By this means, the sliding channel is made to rise a distance equal to twice the effective length of the piston. To permit use of short hose line and minimize flexing, hydraulic connection to the cylinder is made through the secondary piston.

DRIVE UNIT consists of motor, controller, gear train, brake and drive wheel. Unit is easily removed for repair. Two bearings secure the drive unit to the truck frame. A tapered roller bearing at the top of the housing carries the entire weight of the truck's front end. Tractive forces are transmitted through a large ring ball bearing. Handle of drive unit controls movement of the lift truck. A commutator assembly is mounted at the end of the shaft on which the handle pivots. The other end of the shaft is cam-shaped and opens the spring loaded brake levers when the handle is moved away from its vertical or horizontal limits. The commutator is in the electrical control circuit and is so arranged that the circuit is broken when the brake is applied.

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Fork Trucks

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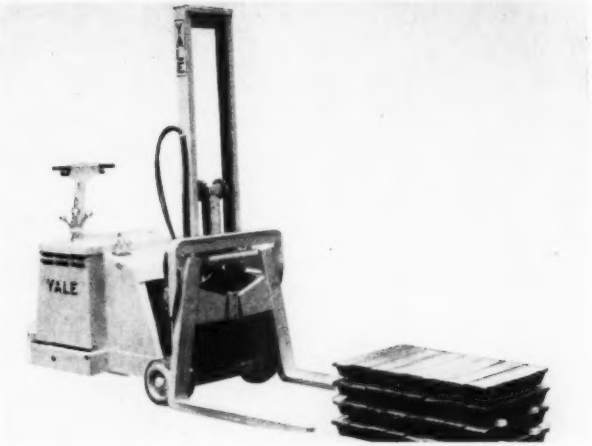
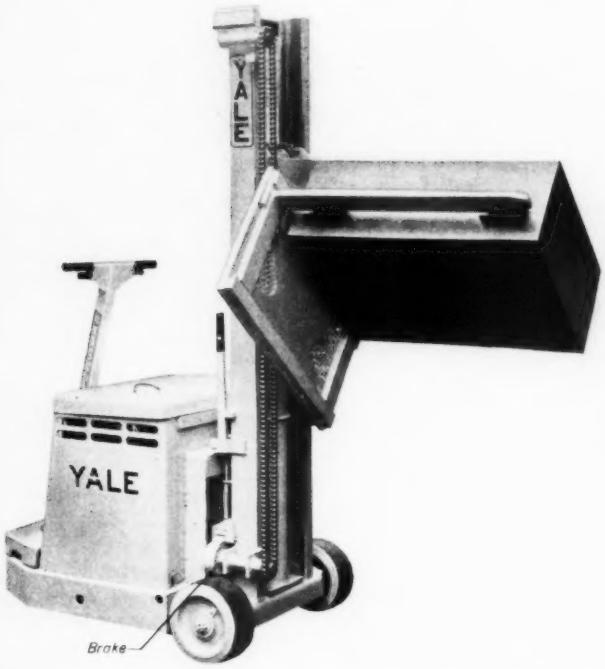
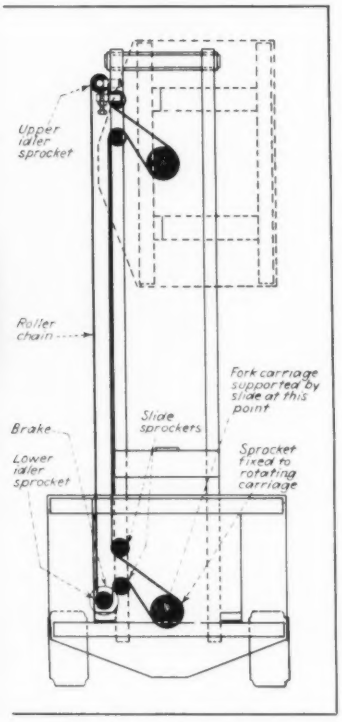


THIS TRUCK is intended for specific applications where it is desired to have the forks exert a clamping action about the material being handled. A double-acting hydraulic cylinder actuates the forks. During the clamping action, there is a tendency for the forks to bend their pivot bolts outward. To overcome this, heavy steel plates are welded to the forks. These plates engage with a slotted guide thus providing a rigid fork assembly.





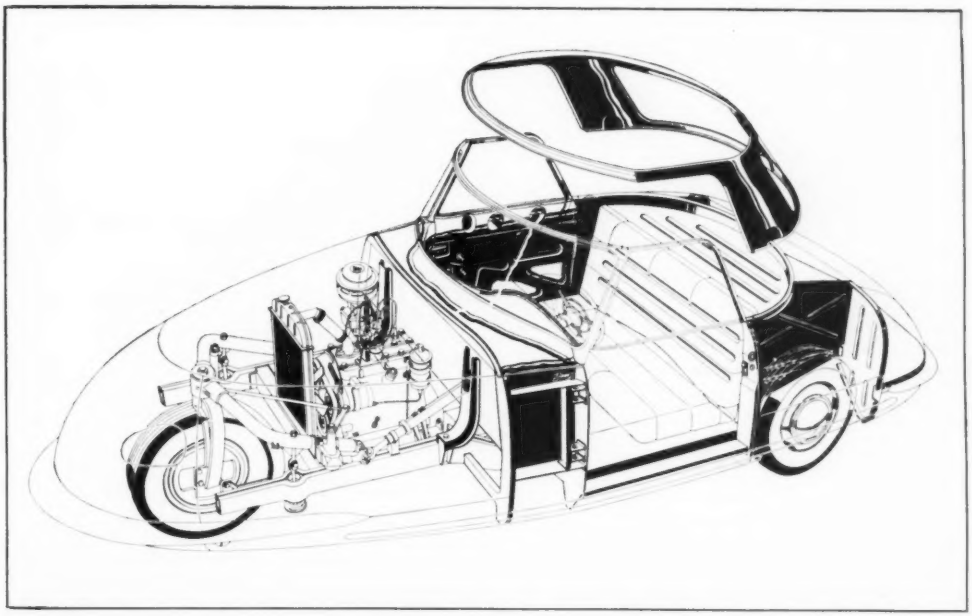
DUMPING OF MATERIALS is possible with this truck which carries a rotatable fork carriage. The conventional truck of this type uses a bull gear and separate motor to rotate the carriage. In this design, the turning effort is supplied by the lift cylinder. Schematic sketch shows the roller chain that controls rotation of the fork carriage. The carriage is mounted on a slide that operates in the truck channels. Normally, as the slide is elevated, the fixed sprocket causes the chain to idle over the upper and lower sprockets. When the brake on the lower sprocket is applied, however, the slide sprockets and the fixed sprocket must rotate. The fork carriage will then rotate with the fixed sprocket. Many attachments are available to adapt forks to the handling of various types of materials.

Three-Wheel Car Has Aluminum Body

Weighing approximately 2,000 lb, the Davis car is powered by a 60 hp four cylinder engine. The single seat carries three passengers. When desired, the aluminum top can be removed and stored in the owner's garage. Locating pins and toggle clamps secure the 43 lb top to the car. The car is manufactured by the Davis Motorcar Co., Beverly Hills, Calif. External skins are applied to frame by means of screws and bolts.

ALUMINUM BODY STAMPINGS do not contribute to rigidity of the car structure. All loads are taken by steel members in the underbody. This design permits complete freedom in styling the body contours. Nose and forward side panels are detachable for easy servicing.

A ROTATABLE FORK carries the single front wheel of the car. This fork is suspended from a yoke member which extends transversely across the frame. Each arm of the yoke pivots about a point just above the side rails. Two coil springs support the front end weight of the car. These coils are secured to the underside of the frame and are put into compression by plunger arms passing through the side rails. Steering is accomplished by a tie rod attached to the wheel fork. The steering gear box rides up and down with the yoke and is therefore connected to the steering column through a universal joint. Standard transmission, drive shaft and differential convey torque to rear wheels.

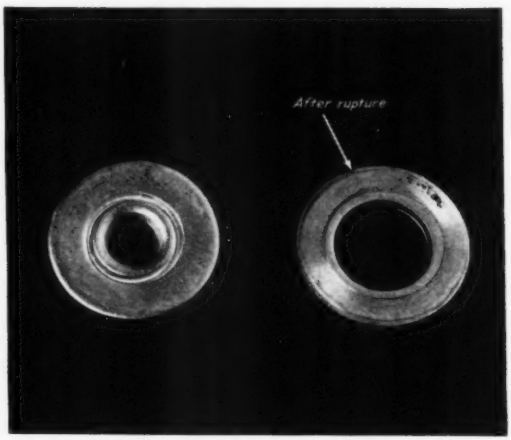


DEEP DRAWN CYLINDER must withstand hydrostatic pressure test of 3,000 psi. Round bottom has been replaced by ribbed shape which not only reinforces cylinder but enables it to stand upright.

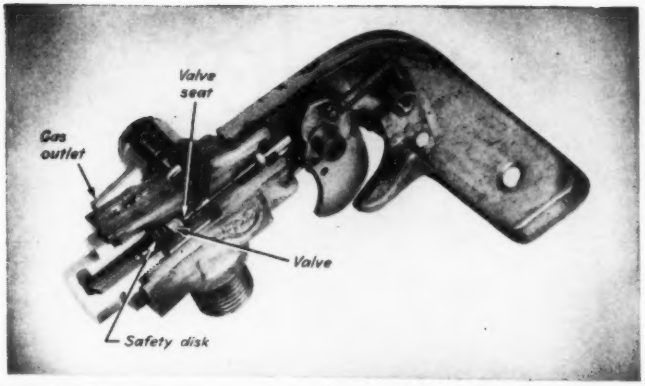
POSSIBLE LEAKAGE POINTS have been reduced from five to two. Gas tightness is further assured because the disk determines the fit at both points. The dimensions of the coined disk are kept between fine tolerances.

Coined Disk Simplifies Extinguisher Valve

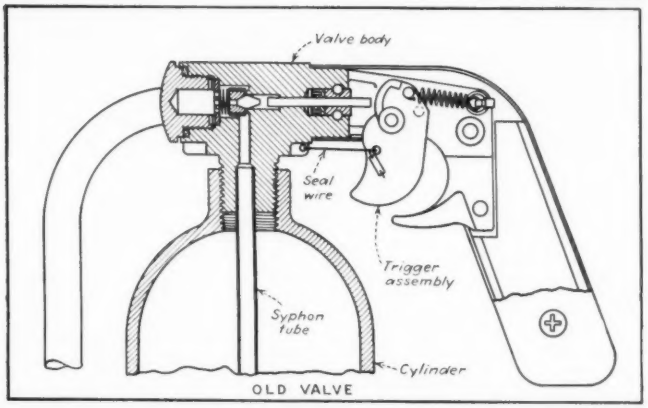
A simple nickel part made possible the general redesign of the valve of this carbon dioxide fire extinguisher. The trigger of the valve now requires less effort to operate. In addition, the possibility of leakage of the gas under 850 psi pressure has been reduced. Engineers of Walter Kidde & Co., Inc., Belleville, N. J., have made these improvements while lowering cost and simplifying manufacture. The extinguisher features an automatic device to indicate when unsafe pressure causes release of gas.



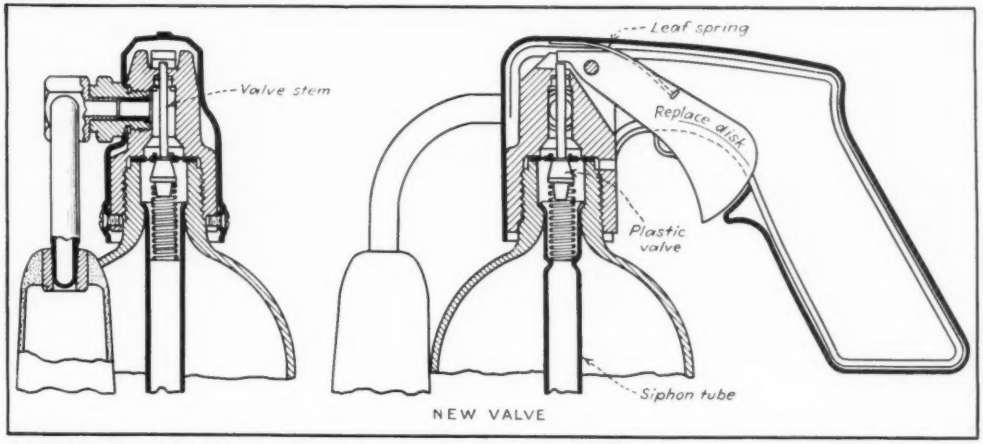
CHIEFLY RESPONSIBLE for the efficiency and economy of the new valve design is this coined nickel disk. This piece acts as a valve seat, a safety-disk and as a washer between the valve body and cylinder. The disk replaces two separate parts and a machined section in the old valve.



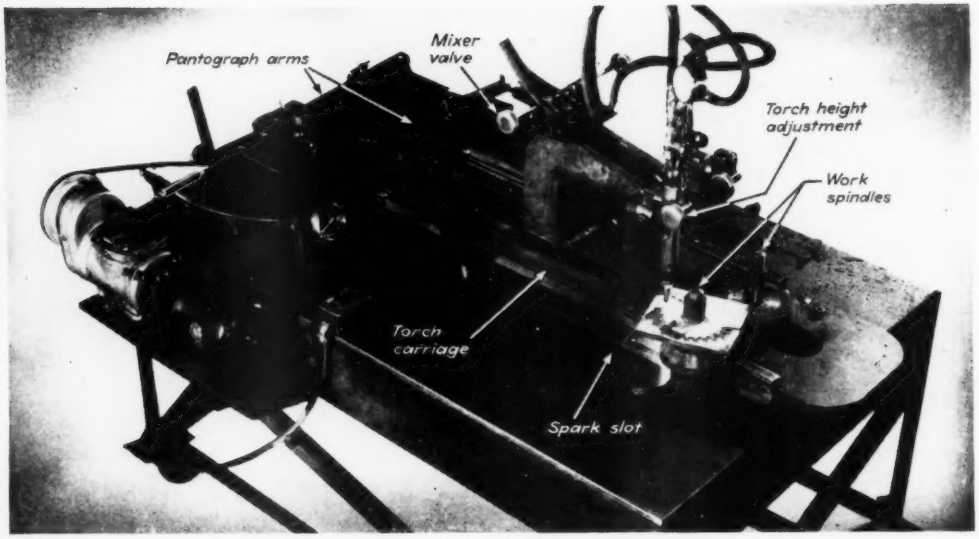
BODY OF OLD VALVE was a complicated and expensive forging having three right angle bends in the escape path between cylinder and nozzle. The new design eliminates two of these bends and thus facilitates gas discharge, a vital factor in extinguishers. The leaf spring now used to cock the trigger replaces the coil spring shown above.



VALVE of the old extinguisher was provided with an external tapered pipe thread. When valve was fitted to the cylinder, this pipe thread had a wedging effect on the neck of the cylinder and tended to weaken it. The new valve employs an internally cut straight thread so that the joint actually reinforces the cylinder neck. In addition, the valve can be removed from the cylinder for test and then replaced without effect on the tightness of the joint. Formerly, once the valve was removed, it was sometimes difficult to achieve a satisfactory connection.



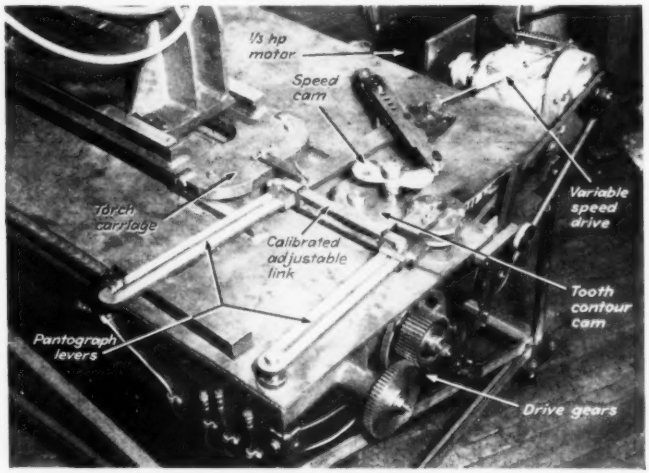
LESS FINGER PRESSURE is required to unseat the smoothly rounded plastic valve of the new extinguisher. The previous valve had a flat surface of comparatively large area. Greater force was needed to overcome resistance of carbon dioxide under pressure of 850 psi. The trigger of the new valve also provides an automatic warning signal should the safety disk be ruptured by excess gas pressure. When rupture occurs, the valve and stem are forced upward. This pushes the trigger downward to bring the words "Replace Disk" into view.



MOVEMENT of oxyacetylene torch and rotation of blank combine vectorially to produce tooth contour. The torch is rigidly mounted on a sliding carriage which operates in accurately machined ways. The spindle in the above is intended for diameters up to 15 in. Second spindle carries the larger blanks.

Cam Shape Determines Contour of Gear Teeth

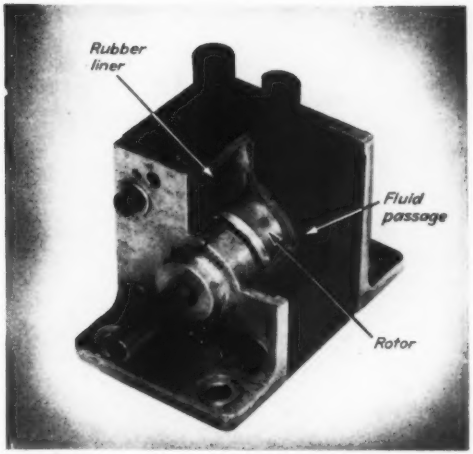
This machine automatically flame cuts gears and sprockets without the use of templates. A cam and pantograph arrangement controls the cutting motion. The cam determines the tooth contour. Adjustments are provided so that several hundred different tooth contours may be traced from any one of the 20 basic cams. The machine, which is manufactured by the Cogmatic Co., Milwaukee, can cut gears up to five ft in diameter and three in. thick.



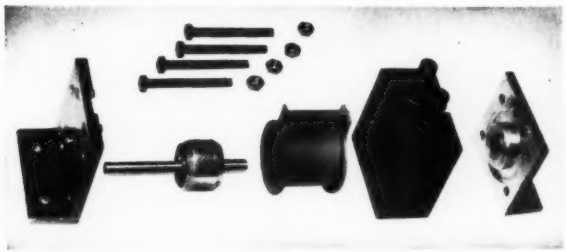
CAM CONTROLS the movement of the torch carriage through a system of pantograph levers. Heavy coil spring keeps follower in forced contact with the cam. By adjustment of the pantograph levers, a variety of tooth sizes can be obtained from a single cam. The variable speed drive unit mounted on the side of the machine is regulated by another cam fixed to the same shaft as the contour cam. As each tooth is cut, four gradual accelerations and decelerations of the work spindle and torch carriage are necessary. These speed variations achieve a constant rate of movement of the flame relative to the cut over all sections of the tooth contour. Major speed adjustments are made by changing linkage which follows contour of speed cam. For any particular combination of contour cam and blank size, change gears determine number of teeth cut.

Rubber Pump Liner For Corrosive Fluids

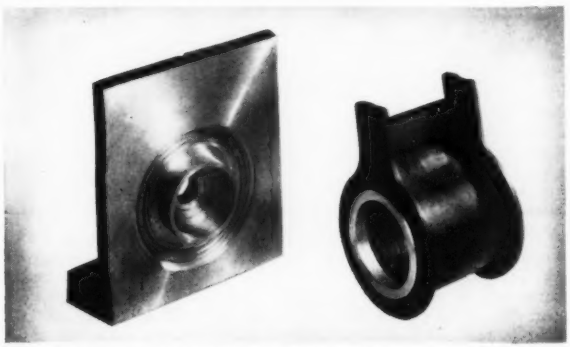
Gaskets and packing glands are not required in this pump for corrosive liquids and gases. The pump employs a liner of molded rubber to activate the fluids and also to seal them from metal parts. An eccentric rotor within the liner causes it to "walk" around the inner periphery of the pump block. This creates an effective pumping action. Under average operating conditions, the liner will require replacement after approximately 2,000 hr of service. The Vanton Pump Corp. of New York City is currently producing these pumps in capacities up to 200 gal per hour.



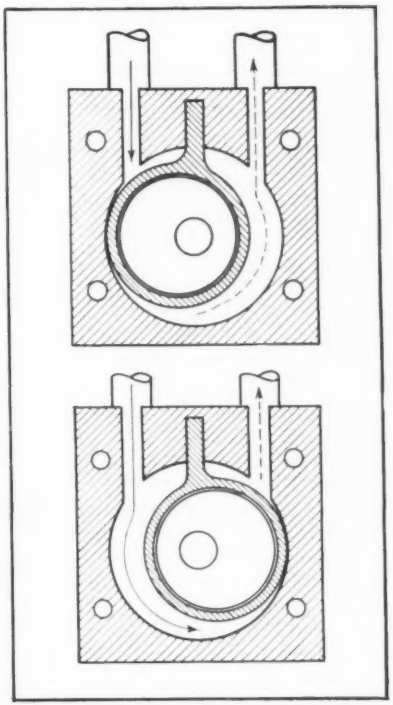
IN PASSAGE through the pump, fluids are confined to space between rubber liner and plastic block. Pump capacity is increased simply by enlarging bore of the block.



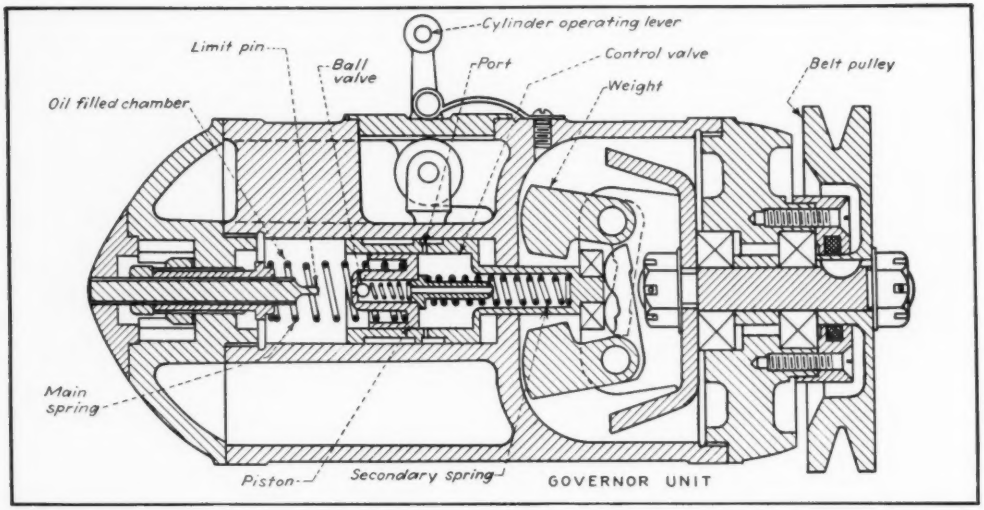
ECCENTRIC SECTION in the drive shaft causes rotor to shift around the bore of the block. The rotor does not turn in respect to the rubber liner. Sealed ball bearings are inserted in each end plate and also between the rotor and the shaft eccentric.



GROOVES in end plates squeeze flanges of the rubber liner tightly against the plastic block. This design effectively prevents the corrosive fluids from seeping past the body and reaching metallic surfaces. Aside from liner flanges, the pump uses no gaskets.



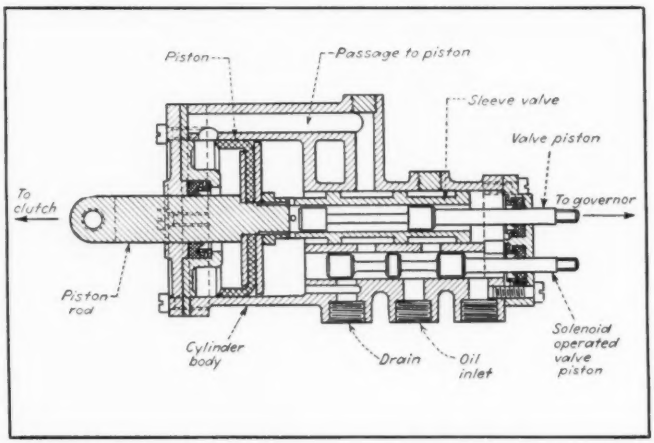
MOVEMENT of the rubber liner pushes fluid through the pump. When run dry, the device can maintain a vacuum of 21 in. of mercury. Pump is easily dismantled for repair.



THE ARRANGEMENT of springs and valves in the governor unit simulates the changing rate of engagement of a driver-operated clutch. As the engine accelerates, the movement of governor weights causes the control valve to shift axially. The control valve actuates a lever which is connected to the hydraulic cylinder. At first, the escape of oil through the valve ports determines the rate of motion. As the clutch faces come into engagement, the piston blocks these ports and the stiff main spring slows the control valve movement. Valve and piston function as a unit until a limit pin pushes the ball valve off its seat. At this point, engagement of the clutch is rapidly completed since only the secondary spring opposes further control valve movement.

Engine Oil Actuates Clutch Pedal

Automatic operation of an automobile clutch pedal is made possible by the Autoclutch developed by the Laystall Engineering Co., Ltd., of London. The device can be installed on any make of car without extensive alterations. While a hydraulic cylinder performs the actual work of engaging the clutch, control of the operation is effected by a governor unit driven by the engine fan belt. At idling speeds, or when engine is stopped, a spring holds the clutch pedal in the disengaged position.



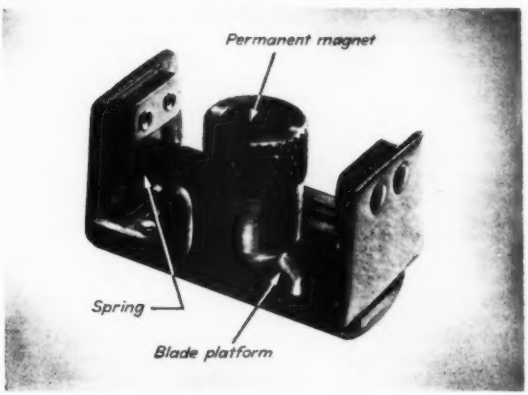
OIL from the engine lubricating system powers the engaging cylinder. As the governor unit pulls the valve piston to the right, a port in the sleeve valve is uncovered. This allows oil from the inlet to flow through the upper passage into the space behind the main piston. The main piston pulls the clutch into engagement. When the engine slows down, the governor will move the valve piston to the left. This closes the inlet port and uncovers a drain port which releases the pressure on the main piston. A switch is provided on the instrument panel of the car to permit driver to disengage clutch while engine is operating at high speeds. Closing the switch causes a solenoid-operated valve piston to shift. This closes oil inlet and opens drain.

Sealed Magnetic Drive for Electric Razor

Two completely isolated electromagnets power the Collins Vibrazor which is intended for soap and lather shaving. There is no mechanical connection between the blade and the driving element. Thus, shock hazard is eliminated. The device, made by the New Electric Razor Corp. of Baltimore, can be immersed in water without harmful effect.

STANDARD double-edge blade oscillates at the frequency of the a-c supply. Amplitude of blade motion is about .025 in. on 115 volts.

Hercules Powder Co.



TWO IDENTICAL MOLDINGS of ethyl cellulose form the razor case. When cemented together, the lower sections of the moldings provide a water-tight enclosure for all current-carrying parts of the electromagnetic drive. Two curved springs, which hold the head in place, bear against indents molded into the upper portion of the case. The head is assembled as an ordinary safety razor.

FLUX LINES passing through plastic case drive the blade platform through a permanent magnet imbedded in knurled nut. The nut screws onto a threaded bolt and clamps together the parts of the platform assembly. Two beryllium copper springs support the blade platform and allow it to vibrate along its length.

How the Patent Office Is Curing Its "Troubles"

JOHN H. MERCHANT
U. S. Patent Office

In this article, John H. Merchant, Editor of the *Journal of the Patent Office Society* and Executive Examiner for Trade-Mark Operations of the U. S. Patent Office, replies to the guest editorial "Cures for the Troubles of the Patent Office", Product Engineering, November 1948, in which H. A. Toulmin, Jr. outlined what he thought was wrong with the Patent Office.

PROMOTION OF OUR PATENT SYSTEM, with its benefits to inventors and the general public, is stimulated by frequent vigorous criticism, constructive suggestions and published discussion. However, unrebutted disparagement of operation and policies of the U. S. Patent Office, and inaccurate ideas of its functions lead to misunderstanding of its important work. In this spirit another side of Mr. Toulmin's article, "Cures for the Troubles of the Patent Office," should be considered.

The statement, that it "takes the Patent Office from eighteen months to two years to answer a letter from its customers who pay the bills," is misleading. Actually, this is the length of time it takes to reach a case for action, *not* the time that elapses before reply is made to a letter received in the ordinary course of business. Such letters are generally answered by the Patent Office in two or three days. An action on an application for a patent is quite different from an answer to an ordinary letter.

An "action" (the name used in the U. S. Patent Office for replies to applications for letters patent) cannot be a simple answer to a letter, or an answer to a "simple letter," as Mr. Toulmin puts it. The patent laws provide for appeals to the Board of Appeals of the U. S. Patent Office, the U. S. Court of Customs and Patent Appeals, and review by the U. S. District Court for the District of Columbia from actions of examiners.

For the best interests of inventors and the public, the Patent Office must guard against being stampeded into superficial examination of applications. The issuance of patents after hasty searches for prior patents and scanty consideration of the question of invention would result only in wholesale invalidation of patents by the courts, or a cruel hoax and economic disappointment to many inventors.

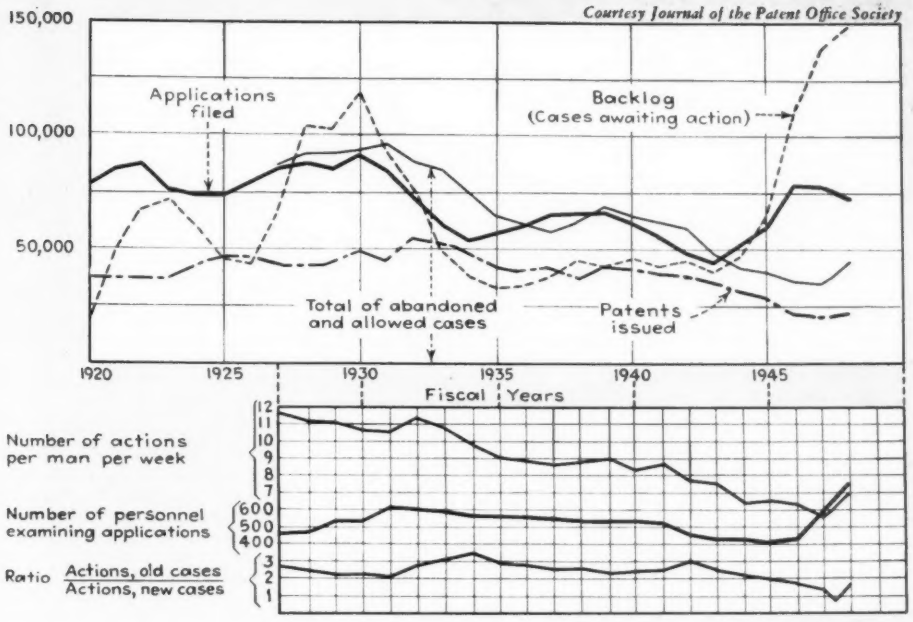
The heart of Mr. Toulmin's criticism is the backlog of pending applications. His contention that "the excuses for the conditions in the Patent Office fade when carefully examined in the light of practicality," ignores or depreciates the extraordinary conditions that contribute to this backlog. The fact that inventors are producing more inventions than ever does not fade, no matter how carefully scrutinized in the light of "practicality." Many industries in the country still have large backlogs of orders that have not yet been filled.

What has the Patent Office done to combat this situation? With almost 146,000 applications on hand awaiting action, and with new cases coming in at the rate of about 65,000 per year, there must be some delays until the Patent Office can expand its force and get space to house that expanded force necessary to handle this unprecedented volume of work.

The Patent Office has increased its examining corps from a total of 411 assistants on V-J Day to the present total of 762. The backlog, which at that time was 66,736 cases, gradually grew until it reached a high on July 1, 1948 of a little over 148,000. For the past six months the backlog has been slightly but steadily decreasing until now it stands at 145,960. The downward trend has been reversed, and the Patent Office is gradually catching up with the work. When it is considered that it takes at least two years to bring newly recruited examiners up to full production, it is evident that the increasing rate of catching up is a positive accomplishment.

As to the length of time necessary to finally dispose of patent applications, the Official Gazette of the U. S. Patent Office shows that of the 577 patents issued on November 16, 1948, the average pendency was about three years, two months. This is not an exceptionally long time, when it is considered that the solicitor or inventor is given six months in which to reply to an action, that solicitors generally amend their applications at least once, and six months is given by statute in which to have the patent issue after its allowance. In fact, the general practice of attorneys is to respond in only a slightly shorter time than the six months' period given them by statute, because of their volume of business and the desire to have the seventeen years' monopoly granted at the latest possible date—so that production problems can be worked out, and commercial possibilities of the matter patented will be greater.

Mr. Toulmin states that "American business does not know where it stands, cannot make investments which are protected, and the patent system has practically gone out of operation."



WHY THE PATENT OFFICE IS BEHIND:

1. Applications now are being received at an annual rate of 65,000, nearly double the 1943 rate.

2. Time lag involved in: (a) Securing authorization to hire; (b) recruiting; and (c) training additional examiners.

3. Overcrowded facilities. At present 40 percent more personnel occupy 20 percent less space than before the war.

4. Increasing volume of literature to be searched. Increasing numbers of patents, books and technical publications lengthen time of search.

5. Insufficient reclassification. More extensive breakdown of many existing classes and subclasses needed to reduce the number of patents classified and searched in a subclass.

6. High proportion of new cases in work load. Initial actions require more time than subsequent actions.

7. Increasing complexity of cases. More complex and detailed subject matter filed and claimed.

8. Development in law and regulations, increasing the work involved in examination of applications.

9. More rigorous prosecution of applications by solicitors and inventors, requiring greater care in the examination of cases. Increasing proportion of applications filed by corporations experienced in their arts, compared with the simpler applications generally filed by individual inventors.

This statement, also, is greatly exaggerated. The majority of divisions in the Patent Office act on new cases within one year, and American business can usually determine on first actions what patent protection it has on an application. When an individual or a corporation can show that it would be helpful to business to have a particular case taken up out of order, it is within the power of the Commissioner, upon proper presentation of a petition and supporting affidavits, to make a case "special" and take it up out of turn.

Mr. Toulmin refers to a slight change made in the interview proceedings about two years ago, in which attorneys were required to make appointments in advance and to prepare an amendment to the case in order to talk to the examiner. This required the attorney to have something basic to talk about before he took up the time of the examiner, and was designed to avoid waste of time in which attorneys without any definite program might come in on a "fishing expedition", to sound out the attitude of the examiner on some future action. This procedure has been modified to some extent and now allows attorneys to interview examiners freely whenever there is reasonable basis for it; as in any orderly business organization, advance notice of appointments should be given.

In observing that the Patent Office procedure is basically simple, Mr. Toulmin fails to make an important point: That an oath and the definition of the inventor's monopoly—the claims—must be presented in an application for a patent. The Patent Office examiner must understand and search for the thing defined by the claims, whether it involves chemical formulas, a complicated electrical control circuit, a new calculating machine, or a new button. He is charged by law to decide whether the subject matter claimed involves invention and is entitled protection for seventeen years by the grant of a patent.

A patent is a contract and should be definite in meaning. Industry and the public should not be unable to determine, because of uncertainty of the meaning of patent claims, what the monopoly granted is supposed to cover.

It is a tedious and time-consuming task to search out and require the correction of the inconsistencies, inaccuracies and ambiguities that creep into patent applications. An examiner cannot search or allow patents on an idea so obscured by verbal "foliage" that not even the trees are visible. The legal obscurations of patent terminology are not the creations of the Patent Office but are inherent in our system, which demands that an invention be distinguished from the myriad of ideas already available to man.

The statement made by Mr. Toulmin—that the Patent Office must grant a patent unless it can find prior patents or publications showing the same thing—is erroneous. The Patent Office has been upheld by the courts many times in refusing patents because no invention was involved.

According to Mr. Toulmin, the Patent Office is in difficulty because it has introduced the legal point of view on matters that are purely engineering and scientific; also that there is no need for a man to be a lawyer to answer the simple engineering questions of whether the invention is new or old. This comment is not well taken. Approximately 95 percent of the examiners of patent applications have engineering degrees; entrance requirements for the position of examiner now demand such technical education. However, many examiners also have legal degrees which are almost invariably obtained by going to school after hours. Legal training is desirable, since the granting of patents is governed by law, and the patent examiner deals with patent attorneys, or other persons with some formal legal training.

Mr. Toulmin discusses "dual prosecution"—prosecution of an application by more than one division of the Patent Office—a practice abolished on November 12, 1948. The practice of "patentability reports" has been substituted; this retains some of the good features of dual prosecution but avoids such objectionable practices as an attorney receiving an action on certain claims from more than one Primary Examiner. Under the new procedure, the entire Office action is embodied in one paper which incorporates the reports of all divisions concerned.

Complains Mr. Toulmin: ". . . the basis of determining invention is left to the individual taste and prejudice of the examiners' so that "the standard of invention varies all over the lot and no one can predict what is going to be done because there are no clear-cut rules for decision." This is unwarranted. It is the right of any inventor to appeal from the decision of an examiner to the Board of Appeals. Decisions of the Board form a standard of invention in the same manner that previous decisions of the courts define the law. Also, five Supervisory Examiners are assigned to assure uniformity in the work of the 71 examining divisions of the Patent Office.

Criticism of confusion arising from the allegedly large turnover among examiners is not valid today. The promotional policy advocated by the present Commissioner, and established by additional appropriations by Congress, has so stabilized the force that in the past six months there have been only 26 resignations by examiners—¼ of 1 percent—to accept positions in outside industry.

Another "trouble" ascribed to the Patent Office is that it "does not follow its own rules and statutes which require the inventor to state with his application what he knows to be the closest patents, publications and prior uses, and how his invention is new." There is no rule or statute that makes such a requirement. The author may possibly have in mind statute R.S. 4888, which, after requiring a complete description of the invention, further states: ". . . and in the case of a machine he shall explain the principle thereof, and the best mode in which he has contemplated applying that principle so as to distinguish it from other inventions." This is not the requirement described in Mr. Toulmin's article.

Similarly without foundation in fact is the statement that the U.S. Statuate requires ". . . that the Patent Office should be given a lead as to the closest subject matter so that they can first determine whether the application is new on the admitted material and then be guided into any other close material in the same neighborhood."

Mr. Toulmin's "specialized searching" proposal is an old expedient that was tried in the Patent Office about seven or eight years ago. In this procedure, searching of applications and writing of actions were assigned to two different groups of examiners. The first group examined the case and made the search; the second group was supposed to rely on the search made by the first group, examine the application and write the office action. It was given a trial in Division 15 of the Office, the theory being to have lower-salaried examiners in the first group and higher-salaried employes in the second group. There were duplications of effort, and the resulting bottlenecks causing the system to be discarded in three months.

It is charged in Mr. Toulmin's article that "that term 'subdivision of labor' is wholly unknown and resented in the Patent Office." This is the very "subdivision of labor" that Mr. Toulmin complains of when he attacks the practice of dual prosecution. Under Mr. Toulmin's plan of using three men, one to search, one to specialize in checking the legal questions, and one to specialize in making the decision on anticipation and conduct the correspondence, the application would have to be read by at least two men. In some cases, reports from the searcher and legal specialist to the correspondent would also have to be prepared.

Mr. Toulmin makes the following statement: "The sooner the Patent Office starts regarding itself as a large corporation set up to make money and give its customers service, the quicker the business will become efficient and pay a profit." The primary function of the Patent Office, as outlined by the Constitution of the United States and as carried on for over a hundred years, is "to promote the progress of science and the useful arts." Would it appear to be to the best interests of the country to change this aim now? Of course, the Patent Office should be run efficiently, but the profit from the patent system cannot be measured merely in terms of dollars and cents. We must look beyond this, to our industrial development, increased leisure, and higher standard of living.

EDITOR'S NOTE: For Mr. Toulmin's comments on these Patent Office views, see the Readers Letters section of next month's PRODUCT ENGINEERING.

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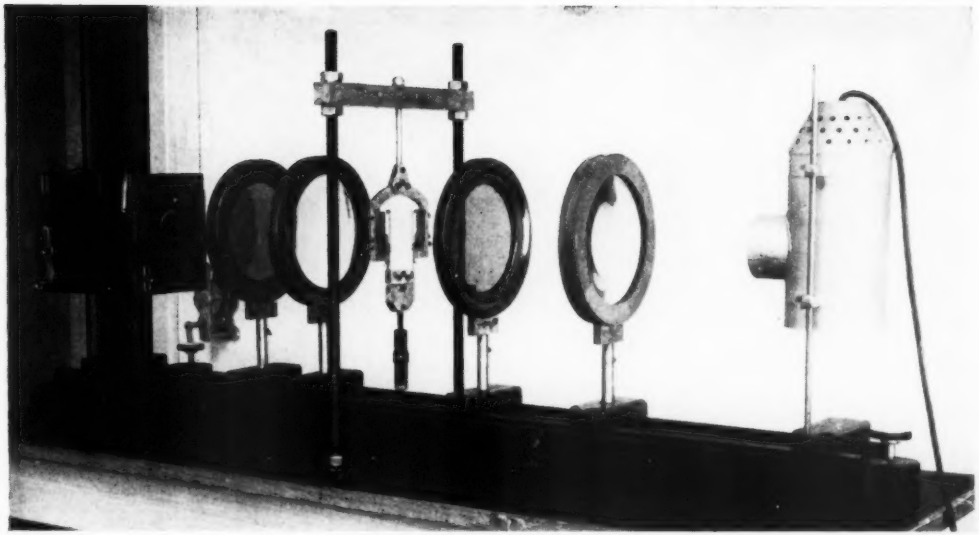


Fig. 1—Photoelastic apparatus, showing model in place for loading prior to the study of the stress distribution patterns.

Improving Bolt Performance

Photoelastic investigation of stresses in bolts shows that stress concentration can be reduced significantly by modifying the contour between bolt head and bolt body, and by annular grooving.

ARTHUR R. ANDERSON
Consulting Engineer

BECAUSE of its complicated system of stress, the selection of bolt size has been largely a matter of experience. When a bolt fails, a larger size or a stronger material is selected. But is this necessarily the only approach to the problem?

Photoelastic investigation indicates that the removal of metal from some parts of a nut or bolt will increase strength substantially. Perhaps the best way of increasing the dynamic strength of fasteners is to reshape them for better stress distribution.

Stress concentrations at sharp corners and sectional discontinuities are particularly serious in dynamically loaded machine components. Threaded fasteners such as bolts suffer from stress concentrations because of sudden sectional changes in the threads and at the juncture of the body and head. The stress distribution is further complicated, and indeed aggravated, by the sudden transition of tension stress in the bolt body to compression stress in the head and the nut. It is apparent that the bolt must elongate with tension; yet on the other hand the nut and the periphery of the bolt head are compressed by stresses of opposite character. Thus, the incompatibility of strain in the bolt adjacent to the nut and head causes conditions of stress too complex to be determined by ordinary analysis.

A study of the nature of stress distribution in bolts was made by the writer in the Research Department of the Bauer & Schaurte Screw Company in Nuess/Rhine, Germany before the war. A simple photoelastic polariscope was built, using a pair of ten-inch Polaroid discs. The apparatus, pictured in Fig. 1, consisted of an optical bench salvaged from an old metalascope, a mercury vapor lamp with filter, a pair of condensing lenses, Polaroid discs, and a simple loading frame.

Test Method

Fatigue tests had shown that failures in bolts were prevalent in two locations: 1. The junction at the bolt and head; 2. through the first or second engaged thread in the nut. Accordingly, these areas were studied with plastic models of bolts and nuts loaded in the frame as shown in Fig. 2. Although the two-dimensional models tested did not conform rigorously to the three-dimensional system of stress in the bolt and nut, it was observed

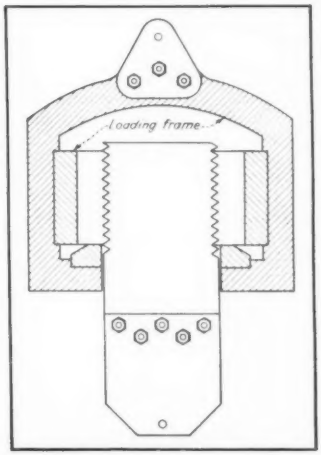


Fig. 2—Loading frame for applying the load to the model of bolt and nut.

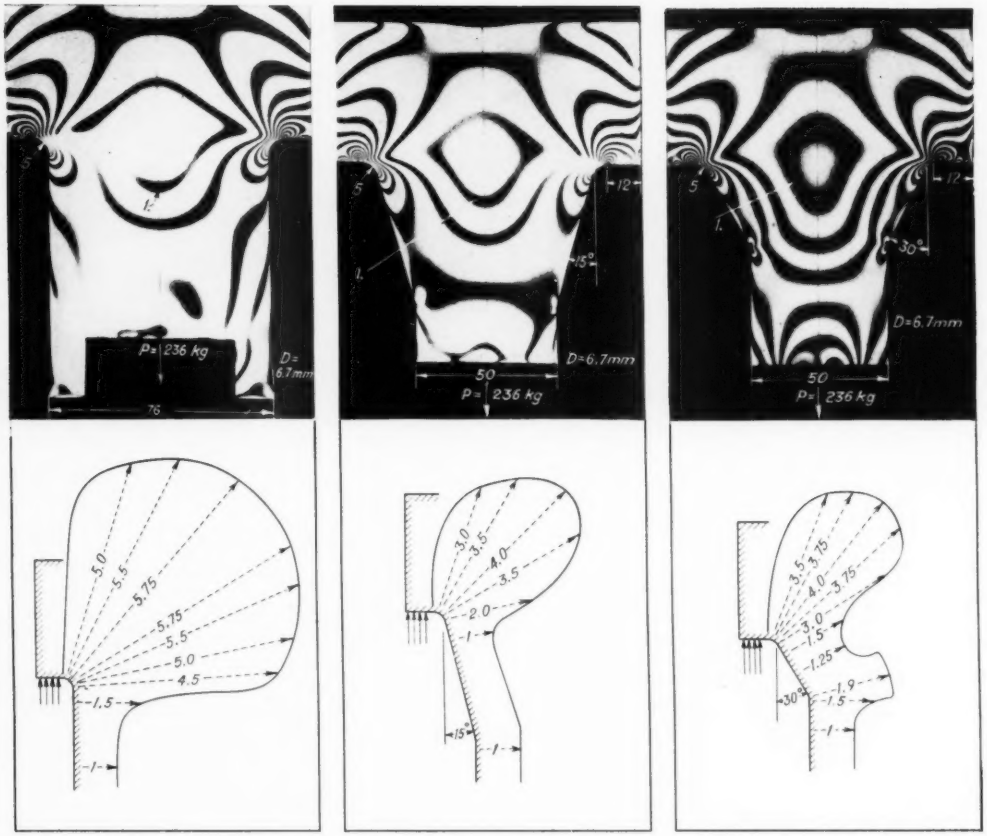


Fig. 3—Isochromatic photograph, and curve of stress concentration factors, 76 mm dia bolt with 5 mm fillet radius at head. Derived from pattern above.

Fig. 4—Isochromatics and curve of stress concentration factors with the bolt diameter reduced to 50 mm and 15 deg conical section added to shank below the head.

Fig. 5—Isochromatics and stress concentration factors, conical section of 30 deg below the head. Stress distribution has been somewhat improved by the change.

that the regions of maximum stress in the photoelastic models coincided with the fatigue fracture locations in the bolts.

Stress Distributions

To analyze the relationship between stress concentrations factors and the shape of the curve from the bolt body to the head, a model was prepared having a body width of 76 mm and a fillet radius of 5 mm at the junction of the body and the head. Fig. 3 shows the isochromatic picture obtained, and the curve of stress concentration factors with reference to the average tension in the bolt. From the curve one notes that the stress suddenly increases from a factor of unity in the bolt body to a maximum of 5.75 near the middle of the fillet. Apparently the fillet of seemingly generous radius is not satisfactory for a highly loaded bolt under dynamic conditions.

To study the value of a gradual transition from bolt body to head, the model was cut in accordance with Fig. 4, in which the body had a 15 deg taper, forming a conical section under the head. From the photoelastic picture a curve was plotted showing a maximum factor of stress concentration amounting to four times the average bolt tension.

In Fig. 5, the transition angle was increased to 30 deg, in which case the maximum stress in the fillet remained unchanged, although a stress concentration factor of 1.9 was observed at the intersection of the conical section and the bolt body.

As a final step, the model was given a recessed transition from body to head as shown in Fig. 6. With this design the tension stress in the bolt body does not suddenly meet the compression in the head; tension stress is more gradually transformed to compression stress along a curved section approximately parabolic in shape. With a transition of this type, the maximum stress was reduced to 3.2 times the average tension stress in the bolt body.

Stresses in Nut Threads

To study the stress distribution in the bolt threads engaged by the nut, a model simulating a section of the bolt and nut was prepared. Fig. 7 shows the photoelastic picture of the model, and the stress concentration factors at the root of the engaged threads.

From the curve of the stress concentration factors it can be seen that the stress in the root of the second engaged

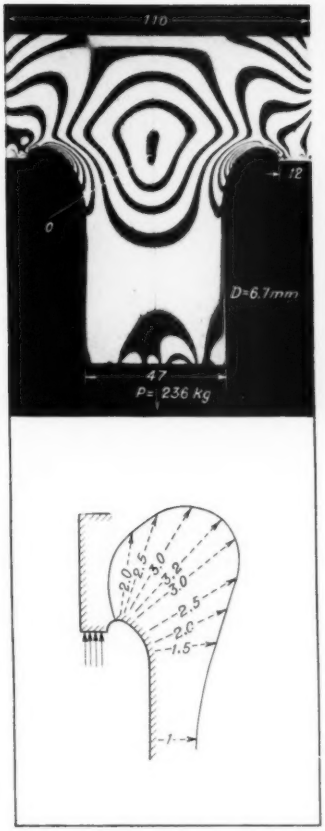


Fig. 6—Isochromatics and stress concentration factors, recessed transition section with parabolic contour. Tensile stresses are eased gradually reducing concentrations.

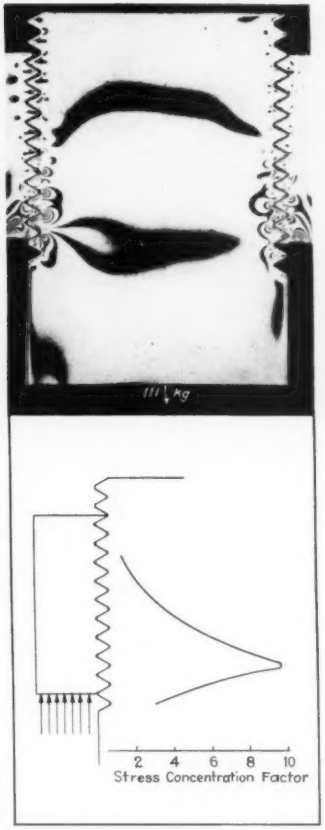


Fig. 7—Isochromatics and stress concentration factors at thread roots of bolt with regular nut. The first few threads cause severe stress concentrations in the bolt.

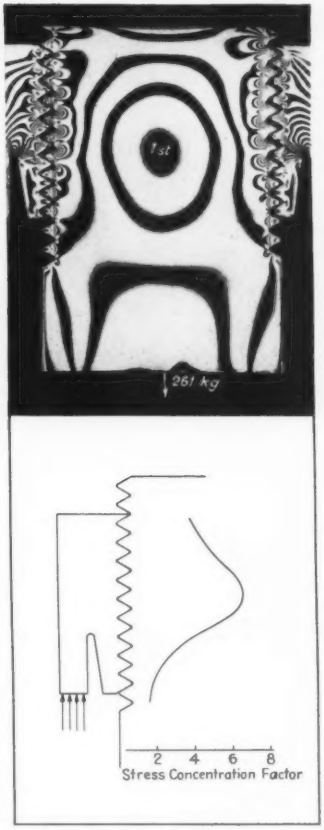


Fig. 8—Isochromatics and stress concentration factors at thread roots of a bolt with a grooved nut. First threads now stretch with the bolt, easing compression.

thread amounts to nearly ten times the average tension in the bolt. From the shape of the curve it is evident that the tendency of the bolt to elongate, and for the nut to compress, produces an unsatisfactory distribution of stress in the threads. The peak stress in the first and second engaged thread, as shown by the photoelastic data, explains why many fractures in dynamically loaded bolts take place at this location in the threaded section.

To alleviate the stress condition in the bolt threads and the engaged nut, a groove was cut in the nut as shown in Fig. 8. With this design, the first three engaged threads of the nut are under tension loading allowing this section of the nut to elongate together with the bolt. From the stress concentration curve of Fig. 8, it can be seen that a much better distribution of stress was obtained, with an appreciable reduction of maximum stress concentration. Undoubtedly, this design could be modified for further substantial improvement.

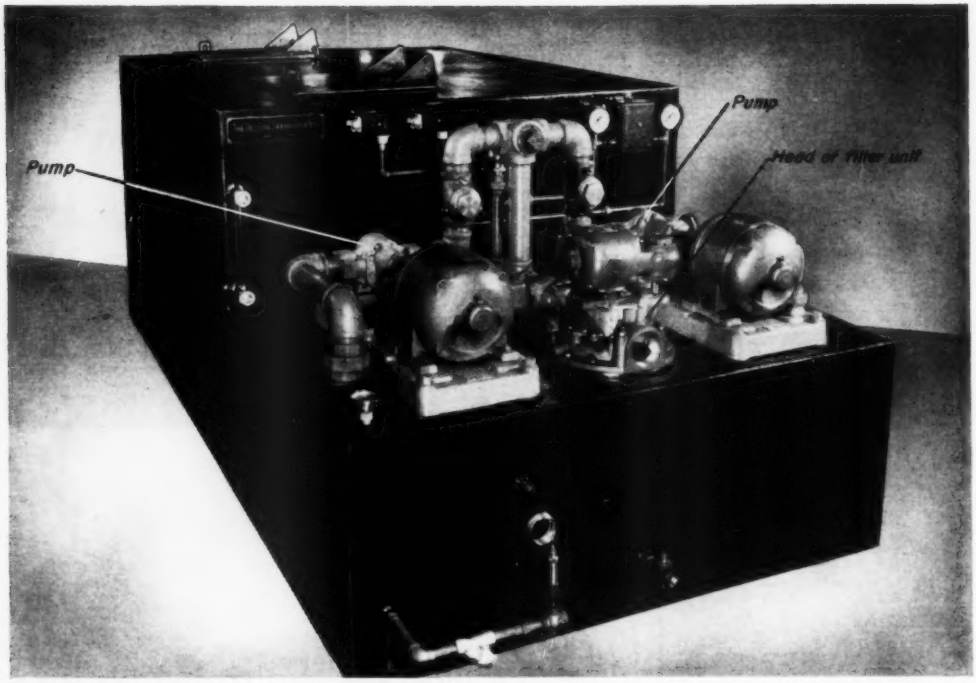
It should be recognized that a photoelastic study of this kind does not yield exact quantitative stress data for the three-dimensional bolt. However, much information of a qualitative nature can be obtained. This understanding will assist the engineer to design contours that allow the transmission of stresses through complex sections with the lowest possible concentration factors. Strength, efficiency and reliability similarly can be improved in many other machine elements.

A Significant Trend In Design . . .

. . . is the use of the unitization principle to make more models available to buyers without a price premium for low run production.

How one company makes 118 different models of compressors with combinations of 24 basic parts is just one of many ingenious cost-cutting ideas to be shown in the June number on

DESIGNING FOR LOWER COSTS



CENTRAL UNIT that delivers heavy lubricating oil at desired temperature, pressure, and quality to bearings and reduction gears. The filter assures a supply of clean lubricant to the sliding parts, rotating parts, valves and packings in the machine system.

Depth and Space Type Filters For Fluid Systems in Machines

Fundamental principles and considerations that govern the selection and application of a satisfactory filter for removing harmful contaminant solids from liquids in lubricating systems and coolant systems. The discussion includes the advantages and limitations of the several filter types, and also the merits of full flow filtration in recirculating systems.

D. H. VAN VLECK
Manager, Sales Engineering Div.,
Cuno Engineering Corporation

HYDRAULICALLY OPERATED MACHINES, machines that are lubricated with force feed systems, and machines that are equipped with coolant handling lines, all include in their design the selection of a filter system for the protection of their sliding parts, rotating parts, valves and packings. Unless the proper filter is used, the results may be disappointing. In the selection of a filter, therefore, it is important to know how different types operate, what they filter and how machine requirements influence the selection of a suitable type.

In this discussion, the word "filter" denotes any mechanical device that separates solids from liquids by using a difference in size as the basic principle of operation. Thus the term "filter" includes devices that employ elements such as stacked disks, slat screens, wire cloth, textile fabrics and textile bats.

As used here, the term "filter" does not include centrifuges because they depend on a difference in specific gravity for operation. Neither does it include tables used in ore concentration processes that operate by means of grooved surfaces and an auxiliary vibratory motion. Nor does it include methods used in the chemical industry for separating and recovering solids from liquids.

Sometimes filters do more than separate solids from liquids, but not often. Occasionally a filter may separate two fluids from each other, but only under carefully controlled conditions and when the fluids are not miscible. In a mixture of gasoline and water, only that portion of the water that is not in solution may be removed by a filter. The action may not be filter-

ing, but may result from the difference in other physical properties such as surface tension. True separation by filtering is dependent only on a difference in size.

Sometimes filters do not do all that is expected of them because this vital point of the nature of the solid is overlooked. Some so called solids are only solids by comparison. Some gummy materials, such as some breakdown products in lubricating oils, are actually fluids though of such high viscosity as to be thought of as solids. A filter may not remove these to the extent anticipated, and thus be blamed for poor performance, whereas it has been expected to do something not the proper function of a filter. Fortunately, a filter can often be used for this type of separation by proper control of operating conditions.

Filters remove three kinds of solids, namely, abrasives, fibers and jelly like constituents, from hydraulic fluids and lubricating oils.

Abrasives are hard solid particles, usually irregular in shape. Suspended in a moving fluid, abrasives cut and wear away metallic surfaces. Also, they can break down oil films on lubricated surfaces. They cut valve seats and passages, orifice and nozzle openings, thus upsetting fluid flow lines, spray patterns and other desirable operational conditions. Sources of abrasives are foundry and core sand in new machines, shop dirt, fly ash, cinders, grinding slush and airborne dust.

Sticky gums and jelly-like constituents are nonabrasive, but they plug inlet and outlet openings of passages thus blocking or restricting normal flow. Also they act as binders that retain abrasives. The sources of these materials are many, but principally they are reaction products of chemical contaminants in hydraulic and lubricating fluids.

Among the fibers, lint is the chief offender. It interferes with fluid flow by plugging passages and by providing a supporting structure for abrasives and gums.

When these contaminants are present separately in a liquid, they can be readily removed with a filter designed specifically for the purpose. But usually they are all present in a variable mixture, thus the selection of the proper filter is difficult.

Types of Filters

Filters may be grouped into two general classes: Depth types, and space types.

DEPTH TYPES are those that offer a relatively long and tortuous path to the passage of fluids. Solids are stopped by becoming entangled within the mass of the filtering structure. The structure may be a fiber mass, either treated or untreated; a ceramic block; or a precoat.

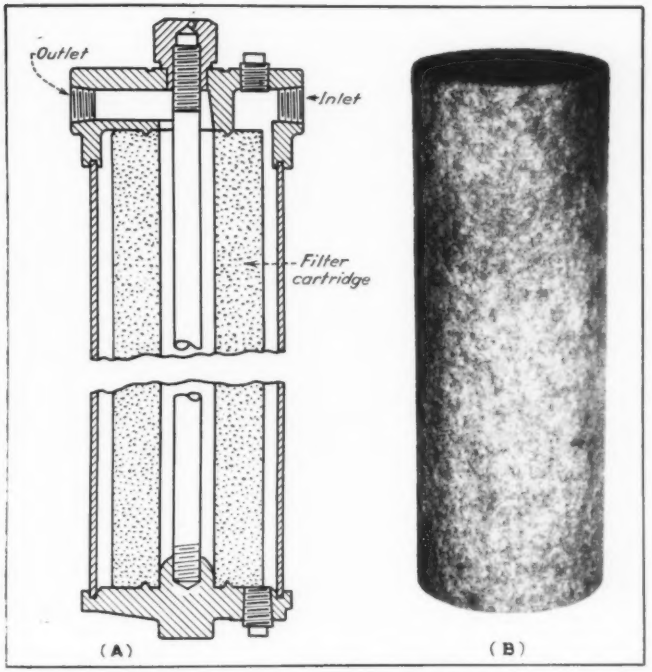


Fig. 1—(A) Depth type filter. (B) Replaceable cartridge having a controlled graded depth density. Structure at inlet surface is more open than that at the discharge surface.

Fiber mass structures consist of packed fibrous materials, usually in the form of a cartridge, Fig. 1. Included in the materials used are felts, woven textiles, blotting papers, and cellulose packs.

Ceramic structures are baked clay porous elements. While they are not ceramic, the porous metal elements may be grouped here since they are functionally the same as the ceramic structures.

Precoats build up a temporary filtering bed on a supporting structure such as wire cloth, canvass duck, or paper. A filter aid such as certain types of clay, diatomaceous earth, or a special proprietary material is mixed in appropriate proportions with the fluid to be filtered. When the mixture is passed through a filter, a cake or bed of the filter aid and the solids to be removed is formed on the supporting structure. The filter aid keeps the cake open enough to pass the liquid but dense enough to stop filterable material.

This bed must be established before effective filtration can be started. This precoating of the supporting structure is done by circulating the charge long enough to establish the cake and until the desired clarity of filtrate is obtained. In the precoat run, the solids will not be effectively removed.

In cleaning the filter, which destroys the bed, the cake is removed from the supporting structure by back-flowing, or by disassembling the filter and manually stripping the cake. Precoat filters usually require auxiliary equipment such as mixing tanks for adding the filter aid, circulating pumps, and change-over valves. Automatic or continuous operation is difficult to obtain.

SPACE TYPE filters are designed to offer a relatively clear and straight path for the passage of fluid, and to stop solids that are too large to enter the opening offered. Examples of space type filters are: Screen, bag, pot, scraper, comb and backwashing types.

Screen, bag and pot types include all the conventional pot types, simplex or duplex, ranging in size from thimble strainers to large trash pots. Their common characteristic is that they must be removed from service for

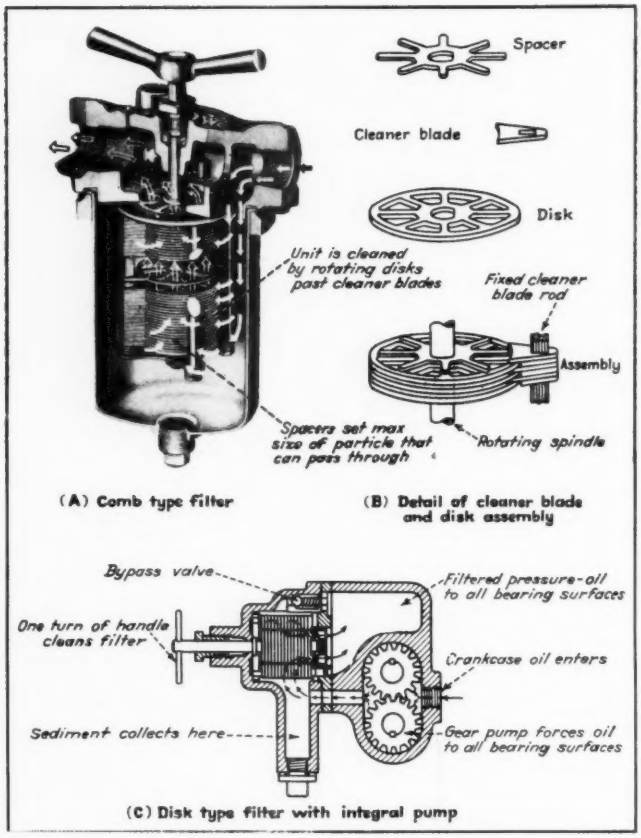

Spacer
Cleaner blade
Disk
Unit is cleaned by rotating disks past cleaner blades
Fixed cleaner blade rod
Assembly
Spacers set max size of particle that can pass through
Rotating spindle
(A) Comb type filter
(B) Detail of cleaner blade and disk assembly
Bypass valve
Filtered pressure-oil to all bearing surfaces
One turn of handle cleans filter
Crankcase oil enters
Sediment collects here
Gear pump forces oil to all bearing surfaces
(C) Disk type filter with integral pump

Fig. 2—Space type filter with stacked disks for a filtering structure. Space between disks is cleaned by combing. (C) A method of building a pump and filter into a machine.

cleaning. These types are used most frequently since they are inexpensive, but as filtering devices their efficiency is low.

Scraper types employ a grid of parallel bars or slats, usually flat. Compared with screens they are easier to clean. Cleaning is done by raking or scraping. In other designs, a wire or ribbon wound cylindrical element is employed that is cleaned by scraping the upstream surface with a doctor or scraper blade.

Comb types use the same filtering mediums as the scraper types. In comb types, however, the space between the bars is cleaned by combing, Fig. 2, rather than surface scraping only, thus cleaning is more positive.

Structurally similar to the cylindrical ribbon or wire wound types are the backwashing types that are cleaned by reverse flow, Fig. 3. The author, however, does not know of any application of this type of filter to lube, fuel or hydraulic oil service.

The existence of a number of types of filters indicates that there is no all-purpose filter. The designer's task is to match the filter to the job. From among the many types, he must select the one filter that has the best combination of the required characteristics for filtering out the contaminations present in a particular fluid.

Removal of Abrasives

Abrasives alone in a liquid can be removed most efficiently by filters that have no moving parts or those in which moving parts are located down-stream from the filter medium. Grinder coolants and cutting oils are examples of fluids in which abrasives alone are found. Filtering such liquids is seldom complicated by the presence of any significant quantity of gums and lint.

Practically all the depth type filters are efficient in removing abrasives alone. They are not more widely used because their dirt holding capacity is limited. In the replacement element types, the cost of elements is high in terms of gallons filtered. In precoat types, the operating charges are high because of the necessity of frequently rebuilding the filter bed.

Space type filters are not as thorough in removing abrasives as are the depth types. Space types are more widely used, however, because of a more favorable balance between cost and performance.

Screen or non-cleaning space type filters usually do not perform well, because if the screen is fine enough to do any good it blinds too easily. Replacement and maintenance costs consequently are high. Economically, types with cloth bag elements are less expensive and are more easily handled. All bag types, however, are uneconomic when large volumes of dirt are to be removed.

Scraper and comb types are not suited to the removal of abrasives, chiefly because they cause excessive wear of the cleaning mechanism. Maintenance costs are therefore relatively high.

Fluid backwash types offer the most satisfactory solution for liquids containing abrasives alone. High initial cost is a deterrent, but low maintenance and operating charges frequently overcome the first cost factor. This type of filter is often employed in large and central system installations.

Removal of Gums

When the problem is not complicated by the presence of either abrasives or fibrous material, the removal of gums, jellies or sticky constituents is not difficult. It can be done to some extent by almost any type of filter, but some are more effective than others.

Depth types in general have a disadvantage in that their fine tortuous passages become sealed off with an impervious layer of slime. This layer when supported by the filter medium is able to restrict and even to stop flow. The short life and tendency to plaster is sometimes overbalanced by the high degree of removal of solids accomplished. The use of such filters in by-pass hook-ups is one economic solution to the problems of getting depth filter quality to a partial degree and still keep costs down.

The fiber mass depth type filter group probably finds its best field in the removal of gums and "goo". The wide range of fibers available, having many different characteristics, make possible many variations in filter structure and mediums. The most effective

filters of the fiber mass group are those that have a graded density, that is, at the surface first presented to the fluid the structure is more porous or open and shades off to a tighter or more dense structure at the discharge face, Fig. 1. The greater the degree of graded depth density, the greater is the resistance offered to plastering by gums and jelly-like constituents.

Ceramic filters are reasonably good in removing gums and goos, but because of the difficulty of controlling porosity little can be obtained in the way of graded density. Because of their uniform density, they plaster easily. Unless justified by some chemical or adsorptive action, ceramic filters are infrequently used when the principal contaminant is gum and goo.

Precoat filters are notably effective in removing gum and goo. The filter aid when properly applied prevents plastering by maintaining a porous medium up to the limits of the capacity of the filter. Because of high operating costs, this type of filtration is only used when other more inexpensive methods are inadequate.

Space type filters, used for the removal of gums and goo, should be readily cleanable to avoid excessive plastering. To be effective, they must be operated at low ratings.

Screens and bags cannot be cleaned while in operation. If operated at low rates, they plaster quickly and blind off, thus making removal and cleaning or replacement necessary. If operated at high rates, the amorphous nature of the solids permits shape deformation so that they can squeeze through.

Scraper types do better than bags and screens because plastering, at least on the outer face, can be prevented by scraper action. The outer portion of those particles that have gained partial passage, however, may be cut off by the scraper thus permitting the inner portions to pass. If the cut particle cannot proceed, it remains as a plug at that point. Plugged openings may result in a loss of capacity sufficient to make necessary a more positive cleaning by removal or replacement.

Knife combing of the passage slots insures restoration of full initial capacity after each combing. With cleaners properly shaped, cut-offs are combed out and not pushed through. In common with all space types, and particularly edge types, flow velocities must be kept low to avoid distorting amorphous materials so that they can pass.

Backwashing types are not readily cleaned of gummy materials, because cleaning is not mechanically positive. No concentrated force can be brought to bear on a point of resistance, since the cleaning liquid seeks the path of least resistance. Consequently, plugging once started grows rapidly.

Removal of Fibers

With liquids not contaminated by the presence of either abrasives or gums, the removal of fibers is not difficult. Since this problem is seldom met with outside of paper mills and wool washing plants, it will not be discussed here. The use of depth type filters can solve the problem; also the use of space types except those that backwash with reverse flow.

Combinations of Contaminants

In practice, unfortunately, it is a rare event when only one of the three basic contaminants is present in a liquid, except in grinder coolant and paper stock. The contaminants occur as a family that dislikes to be separated from each other. Each has characteristics that make it difficult for one filter or for three filters either to remove any one contaminant singly or all three together.

Two objections arise to the use of three filters, one for each type of contamination: (1) The designer wants only one filter, and (2) the difficulty in deciding which contaminant will be removed first.

Assume the particular liquid to be filtered contains lint, abrasives and a generous amount of sticky constituents. A screen will stop the lints and fibers, but the gummy materials will cling to the filtered lints and thus stop flow. A fiber mass depth type filter will remove the gums, but the abrasives will load the element while the fibers will provide an additional support structure upon which the gums will plaster. An edge type with combs will remove the gums and fibers, but the abrasives will wear away the cleaning or combing mechanism. A depth backwash type will remove the abrasives until the gums and fibers stop flow and make cleaning difficult.

When the three basic contaminants are present, it is obvious no filter nor any group of three filters will over a length of time perform satisfactorily when removing all contaminants.

To select a suitable filter for any particular application, the contamination to be removed must be evaluated in two ways: (1) What are the relative proportions of the amounts of each contaminant? (2) What is the

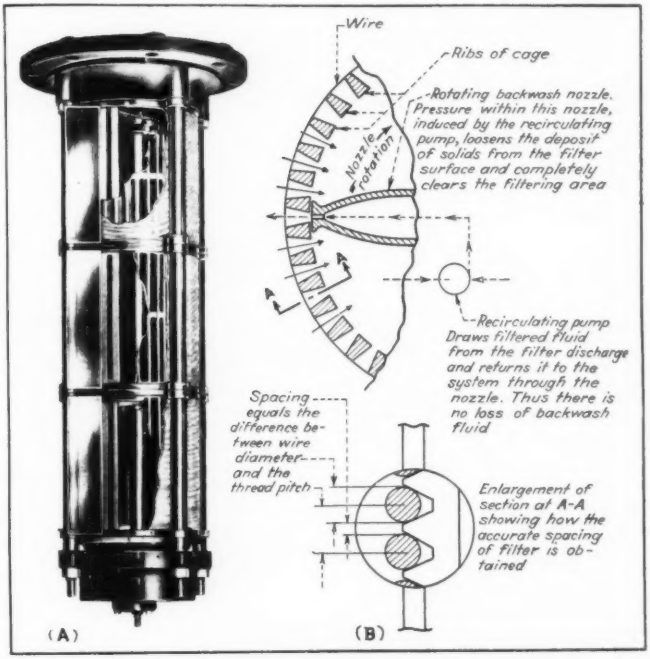

Wire
Ribs of cage
Rotating backwash nozzle. Pressure within this nozzle, induced by the recirculating pump, loosens the deposit of solids from the filter surface and completely clears the filtering area
Nozzle rotation
Recirculating pump Draws filtered fluid from the filter discharge and returns it to the system through the nozzle. Thus there is no loss of backwash fluid
Spacing equals the difference between wire diameter and the thread pitch
Enlargement of section at A-A showing how the accurate spacing of filter is obtained
(A)
(B)

Fig. 3—Wire wound cage filtering structure with backwashing arrangement. Cage has radial slots. Wire is wound in a screw thread groove cut on periphery of the cage. Space between wires determines fineness of filtration or particle size that can pass.

effect of each contaminant on the system or machine that is to be protected?

Answers to these questions will govern the choice of filter type to be applied in any specific problem. The first rule is to select a filter that will remove those contaminants that are most objectionable, and then tolerate those that are relatively harmless.

Any fluid fed to any machine, of course, should be as free of contamination as is possible. The evaluation consists of determining how much cost can be justified in obtaining this objective. In general, it does not pay to do more than remove all particles that could become lodged in the smallest fluid passage, which includes running clearance between moving parts.

A maximum clear opening through the filter medium of one-half the size of the smallest machine clearance, as a rule, approaches the economic balance between cost and degree of filtration. Finer filtration is, of course, desirable but is likely to be too costly.

For example, there is little economic justification for filtering oil to a few microns for a large sleeve bearing having a clearance of 0.008 to 0.010 in. The few particles that would pass a filter opening of 0.004 to 0.005 in. should also pass the clearance with little damage to the bearing. If cost is not an important factor, finer filtration might be desirable to avoid rupturing the oil film.

In industrial fuel oil applications, another example is frequently encountered. In a steam or air atomizing burner, even though the smallest nozzle opening may be 0.030 in., an extremely fine filtration may be specified. Such a specification is costly both in terms of filtration and of fuel. A considerable portion of the contaminant in fuel oil of the heavier grades is carbon or carbonaceous matter having a high Btu content. Taking such material out of the oil, if it can get through the burner, is wasting fuel.

In specifying degree of filtration, it must also be remembered that a relatively coarse spaced filter will stop a great many fine particles, particularly if the velocity is low. Every particle small enough to pass will not be stopped, but a large portion will be. The percentage stopped increases the nearer the particle size approaches the size of the filter opening. The phenomenon is analogous to that observed when trying to throw stones through a chicken wire fence; a stone half the size of the openings rarely goes through.

Doubling the spacing of a filter, without increasing the size of the filter or element, does not increase the cost. Yet by virtue of the lower velocity no practical loss of degree of filtration is experienced; in some applications performance has been improved. The same improvement might be obtained by keeping the velocity low and using finer spacing, but the filter would have to be larger and consequently would cost more.

Using spacings that seem at first glance to be coarser than desirable is even more practical in recirculation systems. Using the chicken wire analogy again, assume that 100 stones each one half the size of the wire openings are thrown. Maybe 20 go through and 80 are stopped. In a recirculation system, the 20 that go through come up for a second pass and on the same basis 4 go through. A wire opening that could not be guaranteed to stop one stone will in 3 passes stop them all.

One of the controversial points, concerning the application of filters, is the relative merits and demerits of full flow filtration as compared to by-pass filtration on recirculating systems such as for lube and hydraulic applications. About two years ago a project was sponsored and tests were conducted at the Armour Research Foundation to determine which method was superior.

In these tests, a series of small diesel engines were operated under duplicate conditions for 360 hours and then disassembled and measured for wear. Also, periodic oil analyses were made to determine acidity, iron, ash and insolubles content. One engine was not provided with a filter; one was provided with a conventional depth type lube oil filter for partial or by-pass filtration; and one with a sufficient bank of the same depth type filter to make full flow filtration possible. The results obtained with full flow filtration were superior in every way, that is less ring wear, less cylinder wear, less bearing wear, and less iron and insolubles in the oil.

The same conclusion is reached when the problem is analyzed on a theoretical basis. Assume that an engine lube system, containing 100 lb of oil, receives from all sources 1 lb of dirt per oil circulation cycle, and that the engine is equipped with a hypothetical 100 percent filter on a by-pass system that handles 10 percent of the flow. In the first ten cycles, 10 lb of sludge will have been added, so that in this period the average increase of sludge content of the system is about 5 lb. Averaging the ten cycles, the filter will remove about 10 percent of the 5 lb, or a $\frac{1}{2}$ lb, per cycle. In ten cycles, the filter will remove $10 \times \frac{1}{2}$ or 5 lb of sludge from the system, leaving 5 lb in the system. The sludge content in the system will increase up to about the 25th cycle to 10 lb. In subsequent cycles the filter will remove the dirt as fast as it is added, but the system will contain 10 lb of sludge.

If in the same system the engine is equipped with a full flow 100 percent perfect filter, 1 lb of dirt will be added and 1 lb of dirt will be removed per cycle. Thus the increase in sludge concentration will be zero.

Since no filter is 100 percent perfect, it would be more practical to assume that the by-pass filter is only 80 percent efficient in removing the sludge fed to it. On this basis, every 10 lb of oil must contain $1\frac{1}{2}$ lb of sludge before dirt is removed as fast as it is introduced. At any given time the system will contain $12\frac{1}{2}$ lb of dirt.

Because of economic reasons, most engine applications could not justify the cost of an 80 percent efficient full flow filter of a size large enough to handle 100 lb of oil per cycle. Assume then that economically the application will justify a full flow filter that is 40 percent efficient in terms of ability to remove sludge. Then with such a filter to remove 1 lb of sludge per cycle, a sludge content of $2\frac{1}{2}$ lb must be maintained in the engine.

From this analysis the conclusion is obvious; a full flow filter of low efficiency can hold down the sludge level in a system better than a by-pass filter of much higher efficiency.

Briefly stated, the conclusions of the foregoing discussion are: Any filter problem can be solved by an intelligent analysis and the application of fundamental principles; no single type or class of filter is the answer to all problems; and the answer to similar applications may not always be the same.

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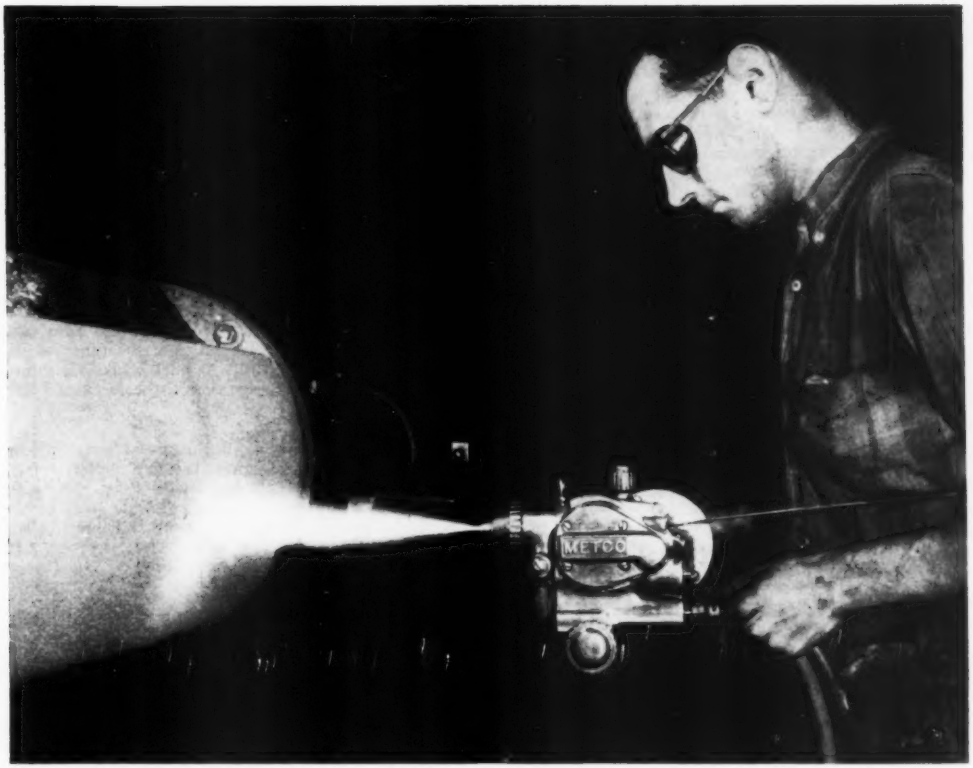

Fig. 1—Wire-type gun sprays 22 lb per hr of atomized steel or stainless steel. This unit sprays consistently and without attention.

Designing with Metallized Structures

Metals applied by wire-type spray guns give specialized properties in local areas. Such properties include improved lubricating qualities, good resistance to wear and corrosion, low cost and improved electrical properties. To be successful, these metals must be sprayed over properly prepared surfaces.

JOHN E. WAKEFIELD
Metallizing Engineering Company

IMPROVED LUBRICATING QUALITIES, high resistance to wear and corrosion, good electrical characteristics, lower frictional heat production, and lower cost are some of the advantages that metallizing offers to the design engineer. Typical uses of this process include protection of turbine shaft packing sections with metallized Monel and stainless steel, copper on carbon brushes and resistors, and metals applied to dielectric panels for producing electrical circuits. In the last application, metallizing eliminates the expensive and tedious wiring and soldering of standard circuits.

Light sections that might be distorted by the heat of hot dipping processes are metallized with zinc, tin, aluminum or lead without damage. Heavy coatings, from 0.010 to 0.025 in., can be applied on tanks, vapor degreasers and similar products, giving much longer protection.

Modern metallizing is done with "wire-type" metal spray guns, shown in Fig. 1. Metal in wire form is fed continuously, by an air-activated turbine and gear train, into an oxy-gas flame. Metal leaves the gun in the form of molten globules, driven onto the work at velocities approaching 600 mph. Because of the heat and high velocity, they flatten out on contact, cooling almost instantly. As other molten particles reach the work, they too flatten out, keying into the original particles. Particles are held together by this physical interlocking, by oxide cementation, and partial welding. Thus, the structure of sprayed metals consists of small and irregular flattened particles, oxides and voids.

Physical Properties

POROSITY. Porosity varies with the metal and the degree of atomization, which is in inverse proportion to the

speed wire is fed through the gun. Porosity can be demonstrated by reduction in specific gravity resulting from spraying, as shown in Table I.

Porosity is advantageous in some applications and detrimental in others. On shaft surfaces, where lubricating qualities are important, sprayed metal coatings absorb and hold appreciable quantities of lubricant, thus operating with considerably less friction than the same metals in solid form. The pores also allow escape of small metallic particles loosened in wearing-in of lubricated surfaces. Both factors contribute to the excellent wear resistance of sprayed metals.

Porosity is a limiting factor in corrosion protection. Metals that are electrochemically cathodic to the base will not protect unless the coatings can be physically sealed. Fortunately, some of the cathodic coatings can be sealed —tin and lead by lightly blasting with round steel shot. Monel and stainless steel can sometimes be sealed by saturating the coatings in raw tung oil or linseed oil mixed with 5 percent by volume of cobalt liquid drier. Other materials, such as special wax sealers, are effective for some applications. However, the sealer itself must be unaffected by the corrosive element.

Therefore, the most promising metals to be sprayed for corrosion protection are anodic to the base. In steel products, this means aluminum and zinc. Although slightly porous, these metals protect iron and steel by "sacrificing" themselves electrochemically.

Table I—Specific Gravity of Sprayed Metals

(Sprayed at normal commercial speeds)

Metal	Specific gravity as sprayed	Percent of Sp. G. of Original Wire
Aluminum	2.408	94.1
Babbitt (Tin)	6.671	86.6
Brass (Yellow)	7.442	88.3
Bronze (Tobin)	7.461	89.2
Copper	7.535	84.4
Iron	6.719	88.4
Monel	7.671	86.5
Nickel	7.551	85.8
Stainless (18-8)	6.934	88.9
Steel (0.010 percent C)	6.673	86.7
Steel (0.80 percent C)	6.356	82.5
Tin	6.426	88.1
Zinc	6.363	89.0

Table II—Shrinkage of Sprayed Metals

Trade Name	Composition	Shrinkage, in. per in.
Sprairon A	0.05 C steel	0.009
Sprasteel 10	0.10 C steel	0.008
Sprasteel 25	0.25 C steel	0.006
Sprasteel 80	0.80 C steel	0.0014
Sprabronze T	Tobin bronze	0.010
Metcoloy No. 1	18-8 stainless (approx. 60 Cu-40 Zn, little Sn)	0.012
Metcoloy No. 2	medium chrome-medium carbon stainless	0.0018

TENSILE STRENGTH AND SHRINKAGE. Tensile strengths of sprayed metals are reduced because of their peculiar structure. This prohibits metallizing for bearing races and similar surfaces, on which there is line or point rolling action. Similarly, tensile strength of sprayed metals is too low for threads and gear teeth.

However, tensile strength of sprayed coatings is seldom a factor for bearing and packing surfaces on shafts, spindles and other mechanical parts. If tensile strength of the base is sufficient for the load, the coating is free to perform its function.

Large power plant valve stems were originally designed to take a heavy bronze sleeve for corrosion protection. Wall thickness was $\frac{1}{2}$ in., with 5 in. OD, the steel stems were 4 in. OD. Redesigned with sprayed aluminum-iron bronze, the stems are $4\frac{3}{4}$ in. with $\frac{1}{8}$ in. on the radius metallized. Overall strength of the stems was increased, and the operation was much faster and less expensive.

Shrinkage of sprayed metals is usually more important than tensile strength. High shrinkage metals when applied in heavy coatings, 0.060 in. or more, tend to crack. Table II lists the comparative shrinkage of several common sprayed steels and stainless steel The harder, high carbon steels and high-chrome, medium-carbon stainless steel have little tendency to shrink. This should be considered in the selection of metals.

Easily machined steels usually have high shrink characteristics. Those with low shrinkage must usually be ground. This may be detrimental, but since the harder metals have greater wear resistance as well as low shrinkage, they are preferred. If grinding facilities are not available and a heavy coating is needed, the bulk of the coating can be of low shrink, hard metal, and the final surface of a softer material.

COMPRESSIVE STRENGTH. No specific figures are available on compressive strengths of sprayed metals; however, tests on different metals indicate a minor reduction, caused by the structure. The compressive strength of sprayed 0.80 carbon steel, for example, is appreciably higher than that of cold rolled steel. Hence, metallized coatings can be advantageous on bearing race fit sections, brake drums and similar surfaces subject to compressive loads.

IMPACT. Oxides and voids, and the chilling effect as the particles land and cool, make all sprayed metal coatings brittle. Brittleness is more severe in the harder metals than in the softer ones. The latter, however, are seldom used for purely mechanical applications. Sprayed metals will not withstand direct impact, and should never be applied to surfaces such as valve seats in internal combustion engines, cam surfaces, dies and punches. However, there are few mechanical parts other than these which take direct impact. Eccentrics such as crankshaft throws, for example, can be metallized quite successfully.

SHEAR. Reduced tensile strength and mechanical bonding make sprayed metals unsatisfactory for applications where shear stresses are great, such as threads, gear teeth and thrust collars. Narrow, sharp edges are not good spots for metallizing.

Lubrication and Wear

Because of the ability of sprayed metal coatings to absorb and hold large quantities of oil, they operate with considerably less friction than ordinary metals. Table III illustrates this reduction in friction.

When lubrication is critical, sprayed metals should be considered. In textile machinery, where large quantities of lubricants cannot be used because of spoilage, journals metallized and soaked in graphited oil materially reduce wear and maintenance.

Wear resistance of sprayed metals is consistently higher than for the same metals in rolled form. Sprayed 0.10 carbon steel is more wear-resistant than ordinary 0.10 carbon. Chilling action from the spraying operation plus a slight increase in carbon content account for this effect. For example, 0.40 carbon steel in ordinary form is fairly easy to machine. Sprayed 0.40 carbon steel is so hard that it must be machined with cemented carbide tips.

Hardness tests are useful only for comparing one sprayed metal with another. Because of oxides and voids, these tests measure porosity and particle cohesion much more than particle hardness. Only a micro-hardness test will give any real indication of the particle hardness, which more than coating hardness, determines wearing characteristics and resistance to abrasion. In Table IV, for example, the Rockwell hardness for 0.80 carbon steel (Sprasteel 80) is listed as C-37 to C-39. However, single particles

Table III—Coefficients of Friction Obtained on Sprayed Metal

(2 in. dia shaft run in complete bearings of white metal, under oil pressure)

Load psi	Plain Oil		Colloidal Graphite Oil	
	Hardened Steel	Sprayed Steel	Hardened Steel	Sprayed Steel
		445 fpm		
250	0.0107	0.0030		0.0021
300	0.00635		0.00255	
400		0.0095		0.00675
500	0.0160			
550	0.0201	0.0124	0.0200	0.0097
700		0.0152		0.0117
750			0.0248	
800	0.0224			
850	0.02625			
900	0.0286	0.0174		0.0132
1,000	0.02175	0.01865		0.0136
1,050			0.0236	
1,200			0.02375	
1,250		0.0184		0.0136
1,300			0.0234	
1,400		0.0174		0.0128
1,600		0.01785		0.0120
1,850		0.0183		0.0112
2,000		0.0179		0.0103
		261 fpm		
200		0.0067		0.0057
250	0.0061		0.0076	
550	0.01315	0.0111	0.01175	0.0098
750		0.0147		
800	0.0169			
850			0.0112	0.0102
1,000	0.0183	0.0149		
1,150			0.0093	0.0078
1,250	0.0176	0.01525		
1,450			0.00865	0.0061
1,500		0.0140		
1,550	0.0160			
1,750		0.0152		
1,800	0.0156		0.0074	0.0039
2,000	0.0153	0.01505	0.00745	0.0029
200	0.0102	0.00745	0.0088	0.0057
550	0.02485	0.0195	0.0209	0.0175
800	0.02475	0.0182	0.0202	0.0156
1,000	0.0276	0.01875	0.0222	0.0162
1,300	0.0318	0.0200	0.02525	0.0169
1,500	0.03125	0.02025	0.0250	0.0161
1,750	0.0331	0.02125	0.0265	0.0147
2,000	0.0352	0.0220	0.0292	0.0143

of this material are close to C-67.

Sprayed metals have greater wear resistance than would be expected from hardness readings. This is supported by field experience as well as laboratory tests in which sprayed steel crankshafts and hardened steel shafts were run in white metal bearings. When the oil supply was intentionally cut off, the hardened steel cranks froze in less than 3 hr. The sprayed crankshafts averaged more than 20 additional hr of operation before seizure.

Electrical Properties

Electrical characteristics of sprayed metals are affected by the presence of oxides. In general, conductivity varies from about 40 to 70 percent of the conductivity of the same metals in rolled form. Oxides of some metals are fairly conductive, so that comparison can only be made for individual metals.

Resistance is similarly affected, varying from about 150 to 200 percent of solid metals. Also, speed of spraying determines the degree of atomization, which affects electrical characteristics.

One sprayed metal that is little affected by these factors is silver. The characteristics of sprayed silver are quite close to solid silver. Actual porosity is the only variable.

Corrosion Resistance

On surfaces that operate in packing, such as pump packing sleeves and hydraulic press rams, hard sprayed stainless steel is a satisfactory and economical solution; this applies to many mechanical parts that are subjected to a combination of wear and corrosion.

On structural steel products, advantages of metallizing stem from the thicknesses to which coatings can be built up. With zinc and aluminum, the protection obtained is in direct proportion to the thickness of the protective coating. It is not much more expensive to apply 0.010 in. than 0.005 in. of sprayed zinc. Cost of preparation is the same for both, so that costs do not increase in proportion to the thickness. Either coating of sprayed zinc would give greater protection than galvanizing, where 0.0005 to 0.002 in. thick coatings are usual.

Preparation and Design

Selection of a method of preparing surfaces for metallizing is of primary importance. One of three types of treatment is necessary on the base, for suitable anchoring of the first layer of particles.

1. The surface must be mechanically roughened, in a manner that provides "anchors" into which the particles can lock themselves.

2. The surface must be preheated, to fuse the particles more completely.

3. An undercoat, which also provides "anchors", must be applied to the base.

Any two or all three of these methods can be used in combination.

MECHANICAL PRODUCTS. In preparing bearing or packing surfaces on shafts, the best method is first threading with a special square threading tool, 0.045 to 0.050 in. wide. Threads are cut 0.015 to 0.020 in. deep except on cast iron where the depth should be from 0.025 to 0.030 in. Threads should be started or stopped at least $\frac{1}{16}$ in. away from any shoulders. After threading or grooving, a special knurling tool, consisting of 5 saw-like blades with staggered tooth set, produces an

Table IV—Hardness of Sprayed Metals

Metal	Rockwell Hardness
Aluminum	H-72
Babbitt (Tin)	H-58
Bronze (Tobin)	F-78 to F-79
Copper	F-78 to F-79
Monel	F-78 to F-79
Nickel	F-86 to F-88
Stainless (18-8)	B-78 to B-80
Stainless (Cr-Carbon)	C-31 to C-33
Steel (0.10 Carbon)	B-89 to B-91
Steel (0.80 Carbon)	C-37 to C-39
Tin	H-10
Zinc	H-46

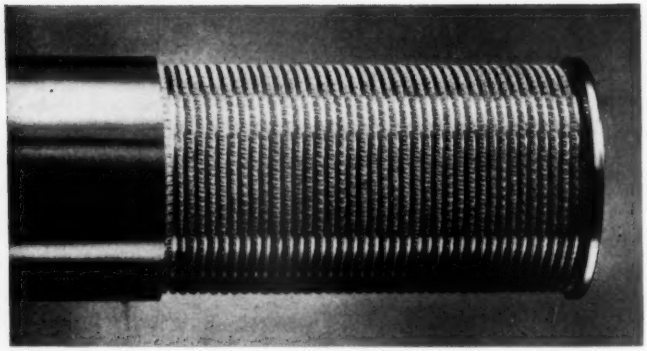

Fig. 2—Preparation of bearing surfaces for metallizing is done by first threading with a special square tool, and then knurling. The latter is accomplished with a special tool consisting of five saw-like blades with teeth set staggered to produce an irregular cut.

irregular cut. Fig. 2 shows a sample shaft prepared by this method. This shaft had to be undercut below the original diameter to allow for the coating thickness. However, as shown in Fig. 3 proper design can often obviate undercutting.

For lighter loads, however, a faster method is to use a 60 deg threading tool to produce a 24-30 pitch thread, followed by the special knurling operations. Threads can be 0.010 to 0.015 in. deep.

Cylindrical surfaces can be prepared by mechanical roughening and an undercoat applied electrically. Equipment used for the electrical deposit is available commercially.

A third method of surface preparation is a recent development, a result of research now being conducted on sprayed metals. In the new method a metal is sprayed with an ordinary metallizing gun, and bonds itself firmly to all metallic surfaces except copper and its alloys. Principal advantages are ease and speed of application. After a roughing cut is taken on the base, a special self-bonding wire is inserted in the gun and a layer 0.0015 to 0.002 in. thick is sprayed on the surface. It bonds firmly even to highly polished surfaces (Fig. 5) if they are perfectly clean, and leaves a surface prepared to receive other sprayed metals, including copper and its alloys.

The roughing and self-bonding undercoat method is satisfactory for continuous cylindrical surfaces such as bearing areas of shafts and journals. However, this method is not recommended on interrupted surfaces, since the shear stress on the bond is considerable; regular threading should be used.

Any surface to be metallized must be clean. In all methods, metal is removed from the base, exposing a clean new surface before any work is done. Preparation should be completed within 1 to 4 hr of spraying. A longer time between cleaning and spraying permits oxidation of the base and a poor bond results.

On mechanical parts which are not cylindrical, such as lathe ways and gibs, threading methods cannot generally be used; the electrical method of bonding is satisfactory, particularly where coatings thicker than 0.040 in. are to be applied. Irregular and flat surfaces can often be prepared with the sprayed self-bonding undercoat, if cleaning is done by sand blasting. This method is adequate for coatings less than 0.040 in. thick.

A low shrink metal can be applied over almost any type of preparation. However, where heavy coatings of high shrink metals are needed, the strongest possible bond should be made. These include square thread with special knurling, V-thread with knurling, and V-thread and electrical or sprayed undercoat.

Thickness of the sprayed coating should be at least 0.010 in. greater than the maximum allowable wear; this prevents rupture of the coating. On surfaces that operate in bearings or packing, the coating should be carried beyond both ends of the wearing area.

ELECTRICAL PRODUCTS. There are few electrical applications where any of the aforementioned methods of preparation could be used. In fact, many electrical applications for metallizing are on materials which need no preparation beyond cleanliness. For example, sprayed copper bonds readily to carbon; 18 or 20 gage copper is sprayed directly onto the carbon, producing a finely textured coating to which connections can be soldered.

On glass and ceramics, the base material is preheated to produce a fusion bond. Heating from 450 to 600 F is sufficient for application of aluminum or zinc. If coatings of higher melting point metals such as copper are desired, zinc or aluminum can be applied as an undercoat, after which almost any other metal can be sprayed. Glass or ceramics can also be prepared by blasting with sand or other abrasives. For plastics and dielectrics, rather than blasting alone grooves should be molded in the panel, in the desired pattern. Then

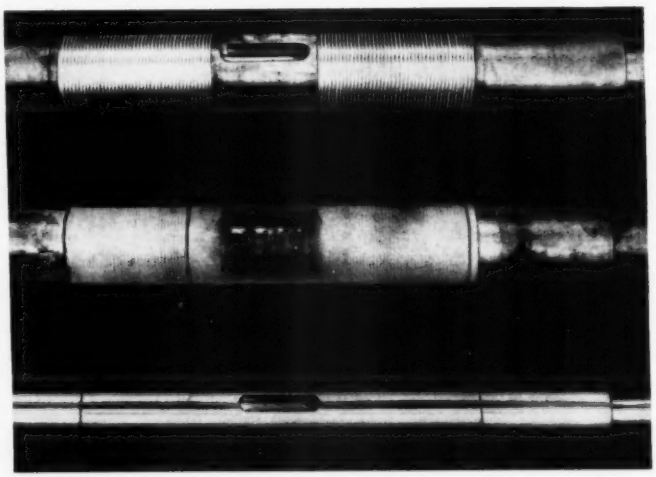

Fig. 3—Metallizing a turbine shaft: Top, preparation by grooving and knurling; center, metallized with high chrome-nickel steel; bottom, finish ground after metallizing.

the entire surface is blasted, sprayed and ground, leaving metal only in the grooves.

Mass production of electrical circuits by metallizing is discussed in an article on page 141, April 1948 PRODUCT ENGINEERING.

STRUCTURAL STEEL PRODUCTS. For corrosion protection, blasting with sand or angular steel grit is the only practical preparation. Almost all such corrosion protection is accomplished with zinc, aluminum, tin or lead, applied in fairly thin coatings. Since the thickness will vary from 0.003 to about 0.025 in., not so strong a bond is needed.

When local conditions make it difficult to blast adequately, bond strengths can be increased considerably by applying a flash undercoat of 0.0015 to 0.002 in. of sprayed steel. This is particularly necessary for surfaces that are to be entirely immersed, and where tin or lead are to be applied.

Cost Considerations

Metallizing reduces cost through saving of materials for original fabrication, saving in time, and often a reduction of machining and finishing operations.

A paper company that manufactures its own rolls originally made them of stainless steel tubing with ends plugged and journals inserted; cost of each roll was close to 600 dollars. By using iron pipe and applying a $\frac{1}{16}$ in. coating of 18-8 sprayed stainless steel, the cost was reduced to 310 dollars per roll, with satisfactory protection.

In the single stage turbine, Fig. 4, 0.8 lb of high chrome, nickel stainless steel suffices for the gland zones on each shaft. If made entirely of stainless steel, each shaft would have used about 58 lb of this expensive material. This particular application also involves a saving in time. Stainless steel does not machine as readily as mild steel. On a shaft with several different diameters machining is much faster when only the gland zones are of stainless steel. Preparation for metallizing is made a part of the rough turning operation; the shaft is sprayed and final finishing includes the stainless steel sections.

High speed of deposition of metallizing also reduces costs. Compared with 3 to 4 lb of steel applied in an hour by welding, a modern metallizing gun easily deposits 20 lb. Comparison with electroplating enhances the value of metallizing still more. For example, it took 4 to 5 days to chrome plate 0.040 in. on 59 in. dia rings. Preparing and spraying these rings with medium chrome, medium carbon stainless steel took 7 hr and 40 min each. Also, the bond under the sprayed stainless steel was much stronger.

Special Adaptations

When metal parts are to be joined to porcelain products, metallizing is valuable. Copper is sprayed on, and metal parts can be soldered easily.

Speed nuts are metallized with zinc on a production basis. After the nuts are heat treated, they are blasted with angular steel grit. Placed in wire mesh baskets set on revolving rollers, they are sprayed with approximately 0.0005 in. of zinc. Operation is much faster than cadmium plating, and standard salt spray tests showed that the zinc gives longer protection.

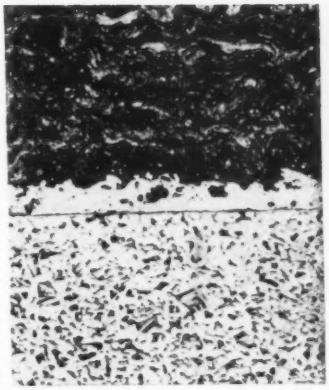

Fig. 5—Metallized structure of steel surface, prepared with a newly developed alloy, which is sprayed on prior to metallizing. At the top is shown the layer of sprayed 0.10 carbon steel; in the center is the sprayed surface treatment, which makes a smooth bond with the cold-rolled steel shaft, shown below.

Metallized coatings of aluminum on cloth are used in production of radio capacitors, giving advantages of high capacity ratio, reduction in size, and stronger tabs for electrical connections. These special aluminum tabs are inserted in the fabric before it is metallized.

Metallizing is also applied for resistance to heat oxidation. Melting crucibles, annealing covers, pyrometer tubes, salt pots and similar equipment can be effectively protected. The process consists mainly of the application of aluminum, special alloys and a proper sealer. While articles so treated will not equal the life of alloy parts, they will outlast unprotected steel parts many times, giving a compromise between cost and extreme length of life.

Discovery of the self-bonding sprayed undercoat previously mentioned has led to two or three other possibilities. In the past, it has been almost impossible to solder aluminum and magnesium. The self-bonding undercoat attaches itself firmly to both of these materials. A flash coating of sprayed copper then makes it possible to easily solder these two materials.

It is also possible now to apply coatings of hard, wear-resistant steels or stainless steel to aluminum or magnesium bases. It seems likely, therefore, that the use of both will greatly increase in the near future, especially for lightweight and wear-resistant parts.

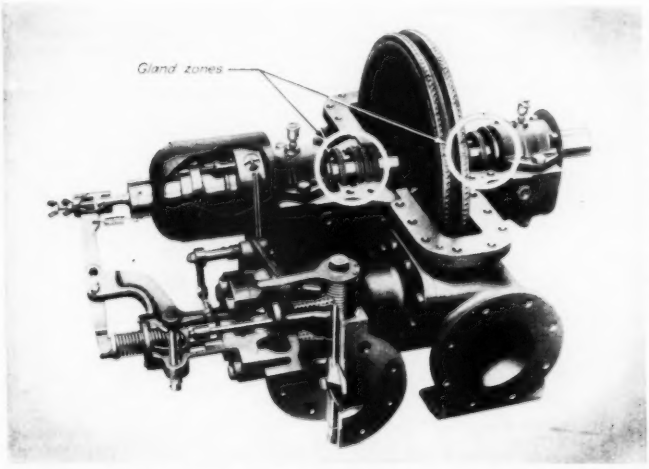

Fig. 4—Cost reduction through metallizing was achieved in this single stage turbine (see Fig. 5). Sprayed on gland areas only, about 57 lb of stainless steel was saved.

Joining Sheet Metal Parts

Methods of attaching rods, tubing and sheet metal parts in permanent

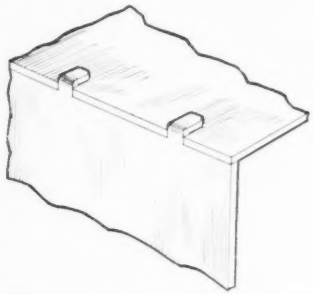

FIG. 1—For butting sheet metal parts at or near a right angle. Two or more tabs are required.

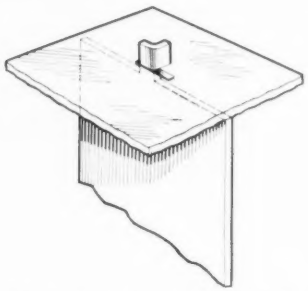

FIG. 2—For applications similar to Fig. 1, but where inaccessibility forbids use of bulky tools.

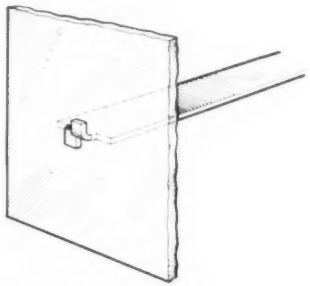

FIG. 3—For use as in Fig. 2, but where greater rigidity is needed.

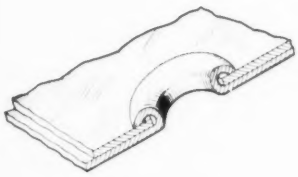

FIG. 4—For permanent attachment of parallel sections. Material must be quarter-hard or softer.

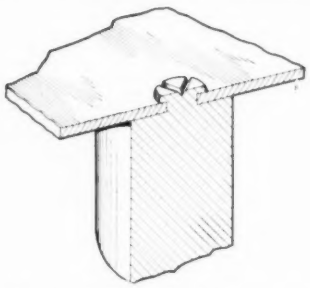

FIG. 5—For positioning shouldered rods in sheet metal. Center-punch as well as "nicking" punch can be used.

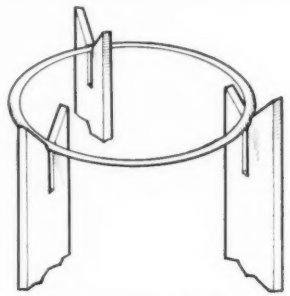

FIG. 6—For temporary support of rods or tubes. Jaws are sprung open during installation and removal.

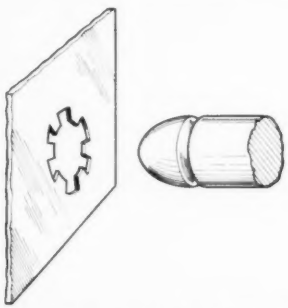

FIG. 7—For semi-rigid attachment. Installation can be permanent or temporary, depending on roundness of rod end and "springiness" of teeth.

FIG. 8—For permanent location of rod in tube. Dents are made after rod is in place. Axial movement can be obtained by lengthening recess.

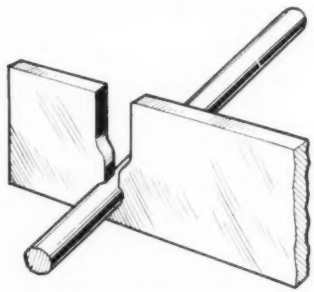

FIG. 9—For temporary positioning of rods in sheet metal. Slots in rod prevent axial movement.

Without Fasteners

or temporary assemblies without using bolts, screws or rivets.

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Chief Engineer,
General Automotive Specialty Co., Inc.

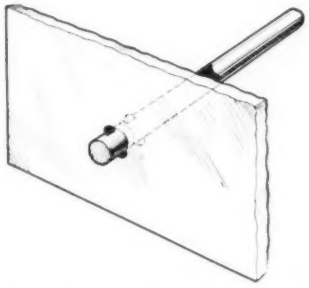

FIG. 10—For permanent assemblies where split forming die can be applied on one or both sides of sheet.

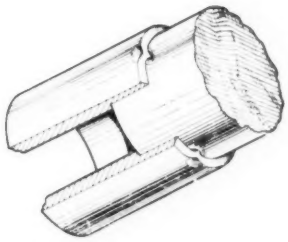

FIG. 11—For attachment of recessed, solid metallic or non-metallic parts in thick-sectioned cylindrical parts.

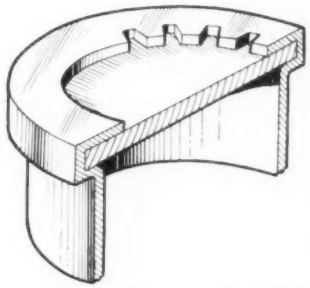

FIG. 12—For closing the end(s) of cylindrical parts. "Toothed" section permits removal of cap, "solid" section does not.

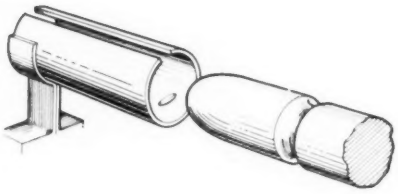

FIG. 13—For bayonet-type electrical fittings. Sleeve and mounting bracket can be modified to suit requirements.

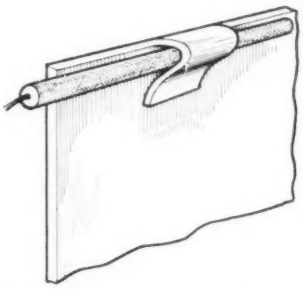

FIG. 14—For supporting electrical conductors.

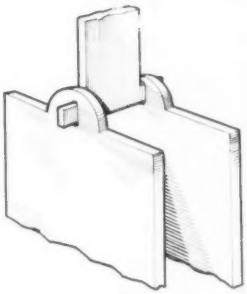

FIG. 15—For permanent assemblies requiring relative movement, but minimum rigidity.

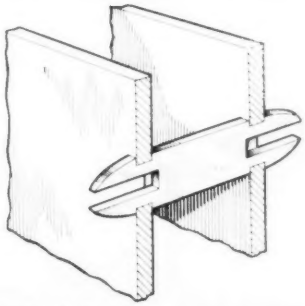

FIG. 16—For temporary use as spacer. Sheet holes can be round or rectangular.

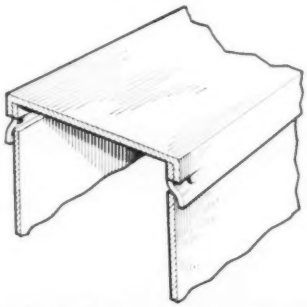

FIG. 17—For attachment of cover to channel or similar assemblies.

FIG. 18—For recessing sheet metal plates in rectangular housings.

Significant Strength of Steels In the Design of Machine Parts—II

Effects of the cold working, surface hardening, and plating processes on the strength of materials used for machine parts. Relationship between fatigue strength and life expectancy in service is correlated, and a practical method of constructing diagrams is described for obtaining allowable stress values for any finite life.*

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IN ADDITION to the factors discussed in Part I of this article, PRODUCT ENGINEERING, April 1949, page 142, the significant strength of materials is influenced by the surface treatment processes, which are applied to improve one or more of the properties of the material. In most instances the process is used primarily to increase properties such as wear and corrosion resistance.

The commonly used processes that effect strength are:

1. Cold working (Shot peening, cold rolling, stretching)
2. Surface hardening (Carburizing, nitriding, cyaniding, flame hardening, induction hardening)
3. Plating (Chromium, zinc, cadmium)

COLD WORKING. In cold working the material is strained beyond the yield point and caused to flow plastically. This plastic flow increases the strength of the steel, but utilizes a portion of the ductility of the material. If strain hardening is carried to excess, the ductility is exhausted and cracks result. Lack of ductility weakens the material, especially in fatigue loading. Heating after cold working tends to relieve the effects of cold working. The higher the temperature the greater the relief.

In cold rolling the outer surface of the material is compressed. In cold stretching the steel is strained beyond the yield point. In shot peening, the part is subjected to a blast of chilled iron or steel shot coming from a rotating wheel or emitting from a nozzle.

Table I—Effect of Cold Working on the Endurance Limit

Steel	Specimen	Treatment Prior to Cold Working	Surface Prior to Cold Working	Percent Increase
SHOT PEENING				
SAE 1020	Plate	As rolled	Polished	9
SAE 1045	Plate	Normalized	Polished	11
SAE 1050	Plate	As rolled	Polished	22
SAE X4340	Standard	Quenched and drawn	Polished	18
Ni-Cr-Mo	Standard	Carburized	Polished	4
Alloy	Bar	Hardened	Polished	2
Alloy	Bar	Hardened	Machined	23
SAE 1020	Plate	As rolled	Hot rolled	34
SAE 1045	Plate	Induction hardened	Hot rolled	50
Rail	Rail	As rolled	Hot rolled	32
0.65C	Wire	As drawn	Hot rolled	42
SAE 1095	Wire	As drawn	Hot rolled	50
Ni-Cr-Mo	Standard	Carburized	Hot rolled	23
NE 9470	Standard	Carburized	Hot rolled	50
NE 9240	Standard	Carburized	Hot rolled	53
NE 8650	Axle	Quenched and tempered	As forged	100
COLD ROLLING				
SAE 1045	Bar	Normalized	Polished	6
SAE 1045	Bored	Quenched and tempered	Polished	52
SAE 1045	Bored	Quenched and tempered	Polished	33
SAE 1045	Bar	Normalized	Machined	27
SAE 1045		Notched	Machined	120
SAE 1045		Notched	Machined	52
SAE 1050	Press-fit	Normalized	Machined	150
3.1 Ni	Press-fit	Normalized	Machined	100
0.35 C	Thread	Quenched and tempered	Machined	53
0.20 C	Bars	Hot rolled	Hot rolled	67
COLD STRETCHING				
	Wire	Patented	Polished	42
0.49 C	Bar	As rolled	Machined	33
0.18 C	Standard	As rolled	Hot rolled	33
	Wire	Patented	Hot rolled	42

Of these processes, shot peening has been most widely used to increase fatigue strength.

Sufficient data are not available to warrant specific conclusions as to the beneficial effect of cold working on the fatigue strength. But data taken from various sources, Table I, indicate that for shot peening the effect varies with the surface of the member before the process is applied. Thus in unnotched specimens, the increase in the fatigue strength for polished specimens seldom exceeds 20 percent, often it is less than 10 percent. For hot rolled specimens the corresponding increase is from 30 to 50 percent, and for as-forged parts 100 percent. This general trend is also apparent in notched specimens although the percentage of improvement is higher.

SURFACE HARDENING. In surface hardening, the surface of a part is hardened to a depth ranging from a few thousandths to $\frac{1}{4}$ in. or more. This localized hardening results in a hard surface layer commonly known as the case, and a softer interior known as the core. Although the hardening

* *The material in this article has been abstracted from the authors' manuscript "Factors of Stress and Strength", which will soon be published in book form.*

is usually applied to provide a long wearing surface, the process affects the strength of the part, particularly under fatigue loading.

In estimating the significant strength for surface treated parts the obvious question arises: What hardness (case or core) does one use in determining the proper significant strength?

Although the hardness distribution over the cross-section does not consist of two levels (uniform high hardness in the case, with a drop to a lower uniform hardness in the core), this assumption may be conservatively used in practical design. Since significant strength (allowable stress) is proportional to hardness, once the hardness distribution is established, the distribution of allowable stresses is known.

The first step in determining whether the case or the core hardness should be used in determining allowable stresses for surface treated parts is to superimpose applied stresses on the allowable stresses. From Figs. 1 and 2, it will be noted that failure occurs either in the case or in the core depending on the type of loading and the absence or presence of a notch. In turn, the zone of failure determines whether the case or the core should be used in estimating the allowable stresses for a particular surface treated part.

Table II—Fatigue Strength of Carburized Unnotched Specimens

Steel, SAE	Diameter of Test Specimen, in.	Case Depth, in.	Hardness		Endurance Limit of Specimens Determined from Test, psi	Endurance Limit of Specimens Estimated from Core Hardness, psi
			Case, R_c	Core, BHN		
2330	0.25	0.041	61	495	157,000	147,000
2330	0.25	0.030	63	514	147,000	139,000
2330	0.25	0.031	61	514	113,000	139,000
2315	0.25	0.041	60	341	120,000	119,000
2315	0.25	0.041	60	341	108,000	119,000
2315	0.25	0.041	60	302	105,000	108,000
2315	0.25	0.042	60	197	101,000	70,000
2315	0.25	0.032	60	197	98,500	63,000

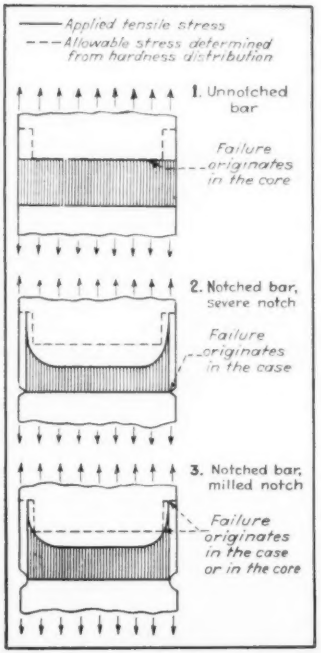
Applied tensile stress
Allowable stress determined from hardness distribution
1. Unnotched bar
Failure originates in the core
2. Notched bar, severe notch
Failure originates in the case
3. Notched bar, milled notch
Failure originates in the case or in the core

Fig. 1—Failure of surface treated parts under axial loading.

For example, in an unnotched bar subjected to bending, the hardness of the core is the criterion of the significant strength. While for a bar with a severe notch the hardness of the case should be used in determining the allowable stress. It is obvious that the significant stress ("applied stress" in Figs. 1 and 2) that should be compared with the significant strength will be different for the two bars.

In the unnotched bar (failure in the core), the significant stress will be the stress at the point corresponding approximately to the junction of the case and core. This stress is obviously lower than the corresponding nominal surface stress as computed from the conventional equations Mc/I or Tc/J. In a bar with a severe notch the significant stress is obtained by multiplying the nominal stress at the base of the notch by the fatigue stress concentration factor.

The fatigue stress data presented in Table II refer to unnotched specimens, for which the criterion of strength should be the hardness of the core. As substantiated by the test data given in Table II, one would expect an agreement between the endurance limit determined from the actual fatigue test and the endurance limit estimated from the core hardness, rather than case hardness.

Presumably the same considerations apply to induction hardened or flame hardened parts. Because of the nature of the processing, however, between the case and core there is a transformation zone that is essentially in a normalized or annealed state. In this zone, the hardness may be less than the hardness in the core. Consequently, in conservative design the hardness of the transformation zone rather than the hardness of the core should be used where the core hardness would be otherwise critical, that is, for unnotched or mildly notched specimens. For sharp notches the criterion of significant strength will be the hardness of the case, as for carburized parts.

Tests on nitrided parts indicate that the endurance limit is unaffected by surface finish for unnotched or moderately notched specimens. Only very sharp discontinuities that cause a large stress concentration will decrease the endurance limit. Consequently, the foregoing considerations for determining allowable stresses are not particularly applicable to nitriding and recourse should be taken to endurance

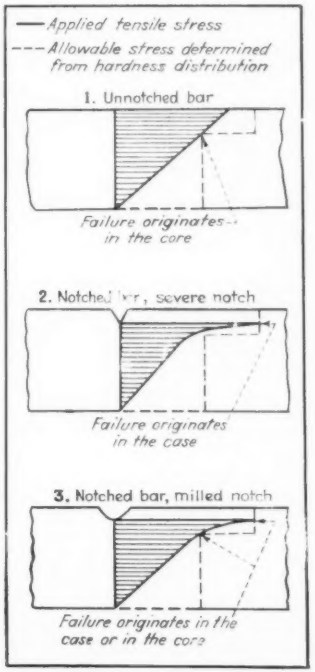
Applied tensile stress
Allowable stress determined from hardness distribution
1. Unnotched bar
Failure originates in the core
2. Notched bar, severe notch
Failure originates in the case
3. Notched bar, milled notch
Failure originates in the case or in the core

Fig. 2—Failure of surface treated parts under bending or torsional loading.

Sym	Steel	Bhn	Ultimate	Reference	Sym	Steel	Bhn	Ultimate	Reference
●	Cr-Ni	247	113,300	17	□	0.37 C	132	59,200	17
○	3.5 Ni	242	111,800	17	◇	SAE	145	76,200	146
△	52 C	227	97,800	17	+	4130	290	139,500	146
▽	0.20 C	---	56,600	17	×	---	432	199,300	146

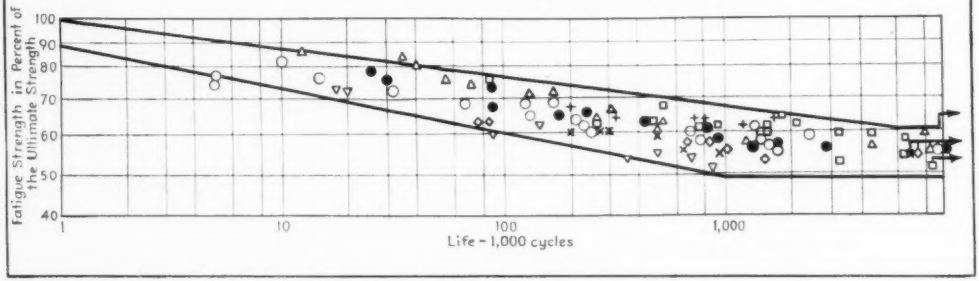

Fig. 3—Relationship between the fatigue strength and life of unnotched polished specimens that were tested in rotating bending.

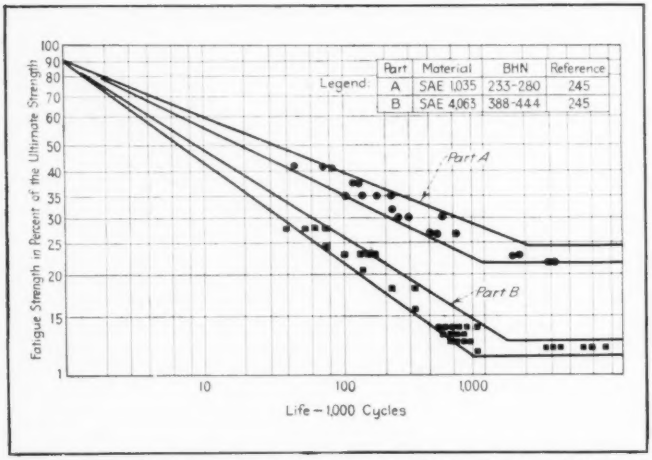

Fig. 4—Relationship between the fatigue strength and life of as-forged fabricated members tested in bending.

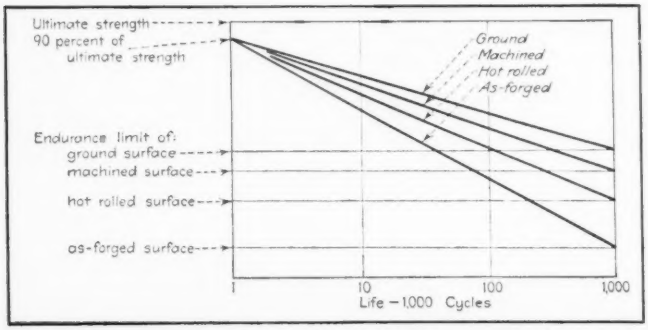

Fig. 5—Fatigue strength for finite life of parts with different surface finishes under alternating loading.

limits experimentally determined. In Table III and IV are given some representative test data for nitrided specimens.

PLATING. Plating is applied to surfaces to prevent wear or as a protection against corrosion, but like most other surface treatments it also affects the strength of the member.

It has been found that the softer electroplating processes such as zinc, lead, and copper have no detrimental effect on the fatigue strength of steel when tested in air. When the tests were conducted in fresh water, however, the plated specimens showed an increase in strength when compared with that of bare steel specimens. This observation would indicate that soft platings offer advantages in fatigue loading on members subjected to corrosion. The data in Table V were obtained by R. Cazaud.

The preceding statement does not apply to hard platings, such as chrome or nickel, when they are deposited in a highly stressed condition or when the conditions of plating are such as to produce hydrogen embrittlement. The detrimental effect is more pronounced in the harder steels. The data in Table VI give an indication of the magnitude of decrease in strength that may be associated with chromium plating.

Effect of Life Expectancy

For most parts, the number of ordinary load fluctuations encountered during service life is well over 10,000,000, consequently the endurance limit would appear to be the correct design criterion for the significant strength. Frequently, the critical load is not

Table III—Fatigue Strength of Nitrided Unnotched Specimens

Steel	Diameter of Test Specimen, in.	Case Depth	Hardness, BHN		Endurance Limit, psi
			Case	Core	
Nitralloy G	0.3	0.015	730	285	82,000
Nitralloy G	0.3	0.015	760	360	87,000
Cr-Mo-Mn	0.75	0.015	700	...	104,000
Cr-Mo-Mn	0.75	0.019	710	...	103,000
Cr-Mo-Mn	0.75	0.016	610	...	102,000
Cr-Mo-Mn	0.75	0.020	680	...	100,000
Cr-Mo-Mn	0.75	0.016	700	...	93,000

Table IV—Fatigue Strength of Nitrided Notched Specimens

Steel	Diameter of Test Specimen, in.	Shape of Notch	Case Depth, in.	Hardness, BHN		Endurance Limit, psi
				Case	Core	
Cr-Mo	0.5	3 in. rad	0.014	705	...	90,000
Cr-Mo	0.5	0.25 in. rad	0.014	705	...	90,000
Cr-Mo	0.5	0.125 in. rad	0.014	705	...	86,000
Cr-Mo	0.5	Sharp	0.014	705	...	69,000
Nitralloy G	0.5	Vee	None	...	285	43,000
Nitralloy G	0.5	Vee	0.015	740	285	82,000

Table V—Effect of Plating on Soft Steels

Condition	Endurance Limit In Air, psi	Endurance Limit in Fresh Water, psi
Uncoated	31,000	15,500
Copper Plated	28,000	28,000
Nickel plated	23,500	23,500
Chromium plated	33,000	33,000

Table VI—Fatigue Strength of Chromium Plated Parts

Steel	Treatment	Plating Thickness, in.	Endurance Limit	
			psi	Decrease from plating, percent
Cr-Mo-V	...	none	74,000	0
Cr-Mo-V	Plated 15 hr	0.0015	68,000	8
Cr-Mo-V	Plated 8 hr	0.006	64,000	14
Cr-Mo-V	Plated 8 hr, tempered 250 C	0.008	31,000	58
Cr-Mo-V	Plated 1 hr, tempered 250 C	0.0015	62,000	16
SAE 6130	Normalized, not plated	none	33,000	0
SAE 6130	Normalized, plated	0.00018	30,000	9
SAE 6130	Normalized, plated	0.0045	32,000	3
SAE 6130	Quenched and drawn, not plated	none	65,500	0
SAE 6130	Quenched and drawn, plated	0.00015	38,000	57
SAE 6130	Quenched and drawn, plated	0.0045	41,000	38

the ordinary load fluctuations, but the overload cycles that may be encountered only a limited number of times (less than a million) during the entire service life of the member. Since the allowable stress increases as the required life diminishes, it is not necessary to limit the allowable stress to the endurance limit values. Obviously, the higher the allowable stress the better the design efficiency. Thus, efficient design demands not only a knowledge of allowable stresses for an infinite life but also for finite life.

The relationship between the fatigue strength and life is shown in Figs. 3 and 4. Note that the curves converge approximately toward 90 percent of the ultimate at 1,000 cycles. The lower ends of the curves reach the endurance limit at approximately 1,000,000 cycles. Thus, knowing the endurance limit and the ultimate strength of a given steel, it is possible to determine the allowable stress for any number of cycles and any surface finish.

The procedure is illustrated in Fig. 5, where both the ordinate and the abscissa are drawn on a logarithmic scale. The diagram gives the allowable stresses at finite life for only alternating loading, since the diagram is derived from the endurance limits that represent the significant strength for a completely reversed stress. To make the data generally applicable it is necessary to include the effect of mode of loading, which can be done by means of the significant strength diagram.

The method of constructing a diagram for finite life that would include all of the pertinent factors is shown in Fig. 6. This diagram is a combination of the significant strength diagrams with both ordinate extended to the ultimate strength, and the limited life diagram, Fig. 5. To determine the significant strength (allowable stress) for a finite life, such as represented by point *B*, determine first the allowable stress for a completely reversed cycle, point *A*, for the surface finish under consideration (in this instance, hot rolled). Transpose point *A* on the ordinate of the upper diagram and connect *A* with *M* by a straight line. Then for a given mean stress *L*, the required significant strength will be given by the ordinate of point *K*. Similar diagrams can be constructed to cover the entire range of hardness encountered in practice.

The foregoing considerations also affect the values of the fatigue stress concentration factor K_f to be used in estimating significant stresses. The fatigue stress concentration factor is conventionally derived on the basis of the endurance limit and conse-

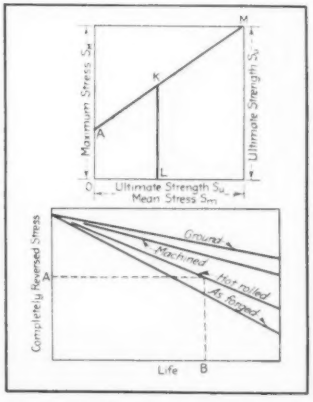

Fig. 6—Significant strength diagram for finite life with all pertinent factors.

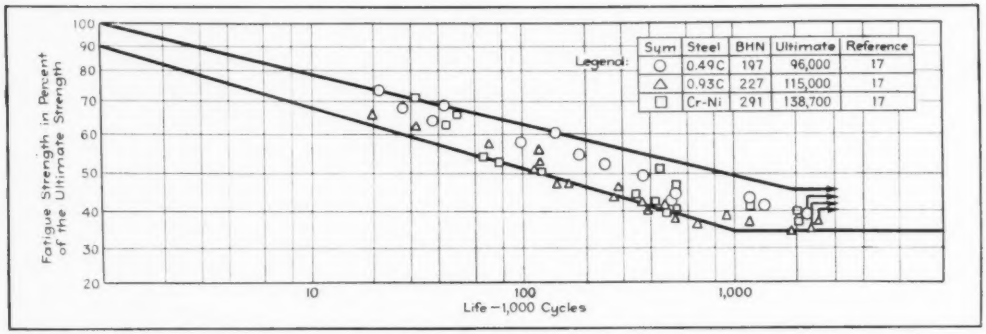
Fatigue Strength in Percent of the Ultimate Strength
Life—1,000 Cycles
Legend:
Sym | Steel | BHN | Ultimate | Reference
○ | 0.49C | 197 | 96,000 | 17
△ | 0.93C | 227 | 115,000 | 17
□ | Cr-Ni | 291 | 138,700 | 17

Fig. 7—Relationship between the fatigue strength and life for notched plates with an edge notch, plates tested in reversed bending.

quently it alludes to an infinite life.

For notched specimens, Fig. 7 shows that the curves converge toward 90 percent of the ultimate at 1,000 cycles, the same as unnotched specimens, Figs. 3 and 4. Hence, the effect of stress concentration, which is pronounced at infinite life but is insignificant at 1,000 cycles, must diminish as the life decreases. The fatigue stress concentration factor K_f' at finite life, therefore, can be derived from the fatigue stress concentration factor K_f for infinite life by means of the exponential law. Fig. 8 shows the resultant relationship.

The effects of percent elongation, which is conventionally used to denote the ductility, are sometimes associated with the strength of a material. This quantity is evaluated in connection with the yield point and tensile strength determination.

Many specifications classify materials according to certain required elongation. The basis for these specifications is an asumption that ductility is associated with toughness and that a high degree of ductility is required to allow the part to deform under load, so that fracture might be prevented.

An elongation of 20 percent is a common requirement for conventional steels, even though most manufactured members could never endure such a large deformation and still be able to function satisfactorily in service. One or two percent elongation is probably all that is required of most parts, with the possible exception of bolted members. It is true that in notched parts subjected to fatigue loading a certain amount of ductility is required, so that the effect of stress concentration at the base of the notch may be diminished. But even in these parts only a few percent elongation is all that is required. Also, the resultant deformation occurs only in a highly localized region.

Another factor that frequently enters into the discussion of the strength of steels is hardenability, which connotes the ability of steel to harden throughout. In parts subjected to an axial loading, the ability of a member to resist an external load will be governed both by the strength of the surface and the strength of the core. For such parts, a steel of high hardenability will provide an obvious advantage. The large majority of load carrying members, however, are subjected in service to bending or torsional loads, resulting in a stress that is maximum at the surface and zero at the neutral axis. For such parts, high hardness in the core is not an essential requirement and steels of different hardenability may exhibit the same service strength.

A factor that does affect the significant strength, though to a less degree than surface finish or mode of loading, is the size effect. Results of various investigators indicate that for unnotched specimens the endurance limit decreases as the size increases, until the critical diameter approaches one-half inch. From 0.5 to 2 in. the endurance limit is approximately constant.

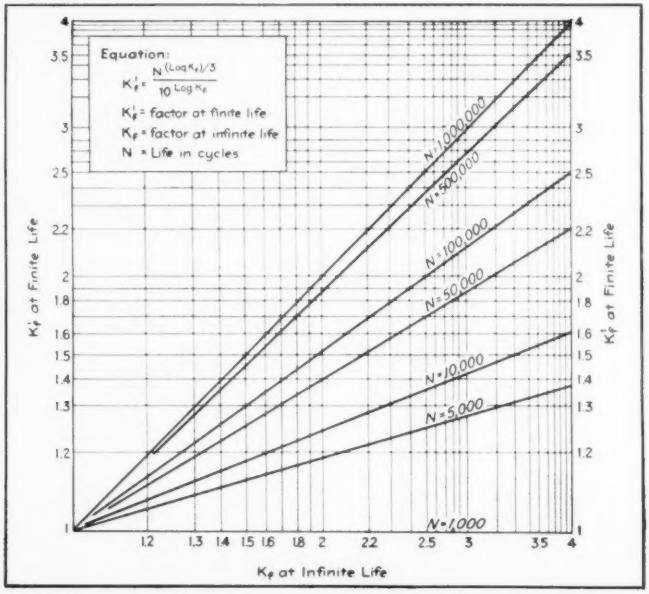

Fig. 8—Construction of diagram for correcting the fatigue concentration factor for life.

EDITOR'S NOTE: The next article in this series will discuss significant stress as related to failure of machine parts, and the effect of abrupt changes in shape on stress distribution.

Torque Reversal and Vibrations In Cyclically Loaded Systems—II

Analysis and procedure for calculating the effects of forced vibration produced by a periodically varying load torque. Harmonic torques resulting from components of gas pressure and reciprocating inertia forces are calculated for an assumed air compressor installation driven through reduction gearing by a turbine.

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AFTER DETERMINING the natural frequencies and tabulating mass and elasticity data for various systems that are equivalent to those for the turbine-gear-compressor installation described in Part I of this article, PRODUCT ENGINEERING, April 1949, p 120, the causes and the effects of forced vibration imposed upon the system remain to be analyzed.

The torque required by the compressor varies periodically thus forcing vibratory motions, even when the stimulating frequencies do not coincide with the natural frequencies of the system. The procedure for calculating the amplitudes of forced vibration is similar to that used for the natural frequencies of the system, except that the values of λ for different amplitudes of vibration are no longer relative, but in accordance with Eq (11) have quantitative values.

In determining the vibratory torque at the gear, over the operating speed range for all the harmonic torques that may affect its value, the tabulation used is similar to that for the natural frequency calculations, except that another column is added for the externally imposed harmonic torques. Table VI shows the method of tabulation.

At the free end of the basic branch the amplitude is taken as λ. Specific amplitude and torque at the junction are then in terms of λ and the harmonic torque M_1 at the compressor in this branch. Similarly for α amplitude at the free end of the second branch, specific amplitude and torque at the junction are functions of α and M_2, which is the harmonic torque at the compressor in the second branch. Those for the third branch are in terms of β. Since the three amplitudes at the junction are equal, α and β can be expressed as functions of λ, M_1, and M_7. In evaluating β the gear ratio must be accounted for. Finally, since the residual torque at the junction is zero, all amplitudes and therefore the vibratory torque at the pinion can be found from M_1 and M_7, the external torques.

The procedure for determining M_1 and M_7 at the various operating condi-

* *The analysis presented is the result of an investigation conducted by the author's company and in which the author took part.*

Table VI—Tabulation Method for Forced Vibration, Fourth Order

F = 2,440 vibrations per minute m^2 = 65,289

	Mass	J, lb in. sec.^{2}	Jm^2, lb in./rad $\times 10^6$	λ, radians	$Jm^2\lambda$, lb in. 10^6	M, lb in. 10^6	$\Sigma Jm^2\lambda + M$, lb in. 10^6	K, lb in./rad $\times 10^6$	$(\Sigma Jm^2\lambda + M)/K$, radians
	1	36	2.3504	λ	2.3504λ	M_1	$2.3504\lambda + M_1$	12.4	$0.1895\lambda + 0.0806M_1$
Basic	2	40	2.6116	$0.8105\lambda - 0.0806M_1$	$2.1167\lambda - 0.2105M_1$		$4.4671\lambda + 0.7895M_1$	6.2	$0.7205\lambda + 0.1273M_1$
Branch	3	19	1.2405	$0.0900\lambda - 0.2079M_1$	$0.1116\lambda - 0.2579M_1$		$4.5787\lambda + 0.5316M_1$	41.8	$0.1095\lambda + 0.0127M_1$
	4	2,458	160.4804	$-0.0195\lambda - 0.2206M_1$	$-3.1294\lambda - 35.4019M_1$		$1.4493\lambda - 34.8703M_1$		

Where the specific amplitude at $J_4 = -0.0195\lambda - 0.2206M_1$, and $T_1 = 1.4493\lambda - 34.8703M_1$

	7	36	2.3504	α	2.3504α	M_7	$2.3504\alpha + M_7$	12.4	$0.1895\alpha + 0.0806M_7$
Second	6	40	2.6116	$0.8105\alpha - 0.0806M_7$	$2.1167\alpha - 0.2105M_7$		$4.4671\alpha + 0.7895M_7$	6.2	$0.7205\alpha + 0.1273M_7$
Branch	5	19	1.2405	$0.0900\alpha - 0.2079M_7$	$0.1116\alpha - 0.2579M_7$		$4.5787\alpha + 0.5316M_7$	16	$0.2862\alpha + 0.0332M_7$
				$-0.1962\alpha - 0.2411M_7$					

Thus, $-0.1962\alpha - 0.2411M_7 = -0.0195\lambda - 0.2206M_1$, or $\alpha = 0.0994\lambda + 1.1244M_1 - 1.2288M_7$,
and $T_2 = 4.5787\,(0.0994\lambda + 1.1244M_1 - 1.2288M_7) + 0.5316M_7 = 0.4551\lambda + 5.1483M_1 - 5.0947M_7$

Third	8	44	2.8727	β	2.8727β		2.8727β	2.36	1.2172β
Branch	9	1.05	0.0686	-0.2172β	-0.0149β		2.8578β		

Thus, $-0.2172\beta = -7.53\,(-0.0195\lambda - 0.2206M_1)$, or $\beta = -0.6759\lambda - 7.6478M_1$,
and $T'_3 = -7.53 \times 2.8578\,(-0.6759\lambda - 7.6478M_1) = 14.5448\lambda + 164.5745M_1$

$T_1 + T_2 + T'_3 = 1.4493\lambda - 34.8703M_1 + 0.4551\lambda + 5.1483M_1 - 5.0947M_7 + 14.5448\lambda + 164.5745M_1 = 0$

$\lambda = -8.1981M_1 + 0.3097M_7$

Consequently, $T_3 = -2.8578\beta = 2.8578\,(-2.1067M_1 - 0.2093M_7) = -6.0205M_1 - 0.5981M_7$

Table VII—Calculated Results—Original System

Stiffness K of Flexible Coupling = 6.2×10^6, lb in./radian

Operating Condition	Harmonic Order				1st	2nd	4th	5th	6th	Driving Mean Torque at Pinion, in. lb
	Operating Speed Closest to Critical Rpm				620	620	610	620	580	
	Compressors				Variable Torque at Pinion, in. lb					
	1	2	3	4						
1	Off	Off	Off	Off	1	639	−550	30	2	748
2	On	Off	Off	Off	164	486	9,495	3,775	841	2,430
3	On	On	Off	Off	171	741	8,268	3,388	1,682	4,112
4	On	On	On	Off	181	1,206	8,949	2,777	2,333	5,795
5	On	On	On	On	2	1,760	−9,034	996	2,983	7,477

Nodes	Natural Frequency, vib/min	Critical Speeds					
		1st	2nd	3rd	4th	5th	6th
1	2,218	2,218	1,109	739	555	444	370
2	2,405	2,405	1,202	802	601	481	401
3	3,170	3,170	1,585	1,057	793	634	528

tions and for the different harmonic orders is described in a later section.

The values given in Table VII show that the fourth and fifth order harmonics actually induce torque reversal at the gears for various operating conditions of the original system. Corresponding results are compiled in Table VIII for the revised system demonstrating the effectiveness of the solution selected. The vibratory torque reduction is very large as is seen by direct comparison.

Table VIII—Calculated Results—Revised System

Coupling Stiffness $K = 0.086 \times 10^6$, lb in. per radian

Operating Condition	Harmonic Order				1st	2nd	4th	5th	6th	Driving Mean Torque at Pinion, in. lb
	Operating Speed Closest to Critical Rpm				580	580	610	610	580	
	Compressors				Variable Torque at Pinion, in. lb					
	1	2	3	4						
1	Off	Off	Off	Off	0	−63	−1	0	0	748
2	On	Off	Off	Off	114	63	6	54	−15	2,430
3	On	On	Off	Off	117	87	4	50	−29	4,112
4	On	On	On	Off	123	122	10	43	−20	5,795
5	On	On	On	On	0	−173	−11	8	−11	7,477

Nodes	Natural Frequency, vib/min	Critical Speeds					
		1st	2nd	3rd	4th	5th	6th
1	373	737	186	124	93	75	62
2	377	377	188	126	94	75	63
	3,106	3,106	1,553	1,035	776	621	518

Harmonic Analysis

In the following discussion an attempt will be made to set down the principles and computation details in a manner suitable for everyday reference.

The torque requirement of a single compressor cylinder is determined by the gas pressure on the piston and by the inertia forces of the reciprocating masses. The gas pressure corresponding to a given angular displacement of the crankpin is obtained from the indicator diagram.

GAS PRESSURE FORCES. Assume that indicator cards taken on the low and high pressure cylinders in the compressor units are as shown in Figs. 8 and 9. The compressors are of semi-radial design with two low pressure cylinders mounted in V-position, each being 30 deg from the vertical centerline, and two high pressure cylinders mounted horizontally. The included angle between successive cylinders is 60 deg. The length of connecting rods is 15 in. The radius of cranks is 3.5 in. Other design data are:

	Low Pressure Cylinder	High Pressure Cylinder
Dia of piston rod, in.	3/8	3/8
Dia of cylinder, in.	15 3/4	9 1/4
Stroke s, in.	7	7
Clearance C, percent of s	7.5	5.3
Compr. ratio P_2/P_1	42.9/14.4	124.4/42.9
Exponent n		
Compression	1.35	1.35
Expansion	1.10	1.10

Where

P_x = any pressure between P_2 and P_1
x = corresponding displacement of piston along its stroke

the following formulas apply

(a) for compression:

$$[(P_1/P_x)^{1/1.35}(s + C)] - C = x$$

(b) for expansion:

$$[C/(P_x/P_2)^{1/1.1}] - C = x$$

The indicator cards for the top and bottom sides of each cylinder are practically identical in value, but are mirrored images of each other.

The gas pressure for any crank position is then obtained from the indicator diagram at the corresponding piston position. Fig. 10 shows the

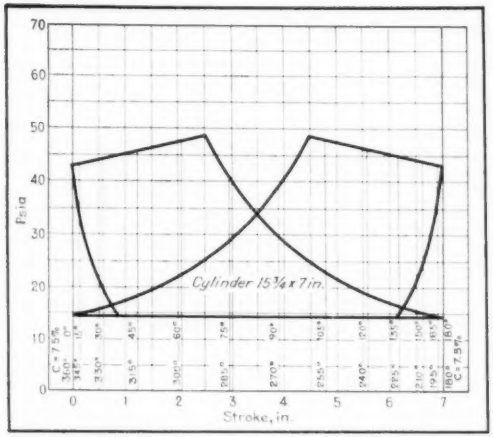

Fig. 8—Theoretical indicator card for low pressure cylinder of air compressor. Positions of crank and piston are shown on card.

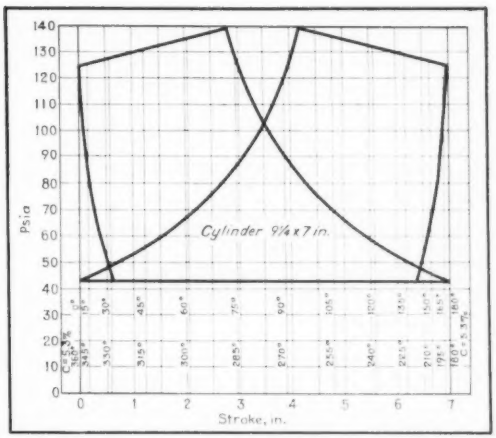

Fig. 9—Theoretical indicator card for high pressure cylinder of air compressor. Positions of crank and piston are shown on card.

relation between piston and crank position.

θ = crank angle measured in direction of rotation from top center, or start of expansion for the top side.
l = length of connecting rod
r = crank radius
$k = l/r$ = ratio of rod length to crank radius

and piston position x is

$$x = l + r - l\cos\beta - r\cos\theta$$
$$= r\,(k + 1 - \sqrt{k^2 - \sin^2\theta} - \cos\theta)$$

where the expression in parenthesis is the crank position factor.

Where

A_h = piston area on head side, sq in.
A_c = piston area on crank side, sq in.
P_h = gas pressure on head side, psi
P_c = gas pressure on crank side, psi
P = net force of gas pressure on crosshead, lb

it is obvious that

$$P = P_h A_h - P_c A_c$$

The torque T resulting from gas pressure is

$$T = (P_c \cos\beta)\,a$$

but since from Fig. 10

$$a = r\sin(\theta + \beta)$$

$$T = Pr\left[\sin\theta\left(1 + \frac{\cos\theta}{\sqrt{k^2 - \sin^2\theta}}\right)\right]$$

the expression in parenthesis is the tangential effort factor.

Crank position and tangential factors for values of k from 3.0 to 5.0, are given in the Reference Book Sheets pages 155 and 157.

With these equations the gas torque for different crank angles for these compressors were calculated and plotted as shown in Fig. 11. It is necessary to determine the torque curve for one high pressure and for one low pressure cylinder only. The total curve for one compressor unit can then be obtained by adding the torques for each cylinder in their proper phase relationship.

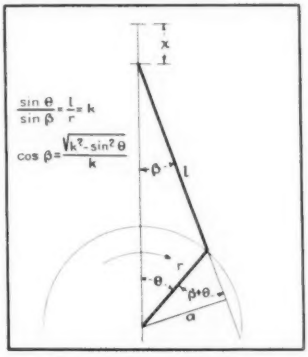

Fig. 10—Relations of rod and crank angles used in deriving the relation between piston position and crank position.

It can be shown that any periodic curve is composed of an infinite number of sine and cosine curves having 1, 2, 3, and so on, complete waves per crank revolution. These curves are called harmonic components of the original periodic curve and are obtained mathematically by harmonic analysis. Fourier's theorem states that any such periodic function y equals $f(x)$, whether in analytical or graphical form, can be expanded as a series of the form

$$y = f(x) = \frac{b_0}{2} + \sum_{n=1}^{n=\infty} a_n \sin nx + \sum_{n=1}^{n=\infty} b_n \cos nx$$

where

$b_0/2$ = the mean value of the function

$$a_n = \frac{1}{\pi}\int_0^{2\pi} f(x)\sin nx\,dx$$

$$b_n = \frac{1}{\pi}\int_0^{2\pi} f(x)\cos nx\,dx$$

It is evident that any constant added to or subtracted from $f(x)$ in the integrals will not affect a_n or b_n. Consequently, the analysis can be made from zero torque as the abscissa instead of from the mean torque line, thus making the determination of

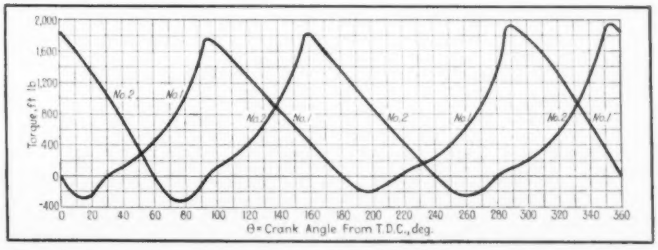

Fig. 11—Gas torque on the compressors calculated for different crank angle positions.

Table IX—Harmonic Components of Tangential Effort Curve

All values in lb in.

9¼ in. High Pressure Cylinder

Order No.	1	2	3	4	5	6	7	8
Sine	138.8	−7,354	−1,558.7	1,195	838.7	−1,136	−725.7	0
Cosine	1,358.2	−7,188	−1,265.7	−409.3	−49.7	−177.3	−8.0	−117.6
Inertia	−506.6	4,298.8	1,530.4	119.4	−17.7	−0.9	0	0
Resultant	1,407	7,810	1,266	1,377	823	1,151	726	117.6

15¾ in. Low Pressure Cylinder

Order No.	1	2	3	4	5	6	7	8
Sine	814.4	−7,964	−1,625	1,117	731.3	−1,216.7	−599.7	31.3
Cosine	1,313.6	−7,189.6	−1,176	−645.7	−252.3	210	191.3	−86.7
Inertia	−662.2	5,619	2,000.5	156.1	−23.1	−1.1	0	0
Resultant	1,359	7,562	1,235	1,427	752	1,236	629	92

torque values with reference to the mean unnecessary.

The integrals can be solved numerically by taking a sufficiently small increment for the interval dx. When

$$dx = 5 \text{ deg}$$

$$\frac{dx}{\pi} = \frac{5}{\pi} \times \frac{2\pi}{360} = \frac{1}{36}$$

$$a_n = \frac{1}{36} \sum_{0}^{2\pi} f(x) \sin nx$$

$$b_n = \frac{1}{36} \sum_{0}^{2\pi} f(x) \cos nx$$

Results of calculations for the first 8 harmonics of the tangential effort torque curve are given in Table IX. The work when calculating can be facilitated by using tables consisting of 7 columns.

The values of $f(x)$ in column (1) are taken from the tangential effort curve corresponding to each 5 deg of crank angle.

In columns (2) and (3) are listed values of the sine and cosine of the angle that is the product of the crank angle times the order number of the harmonic being analyzed.

In columns (4), (5), (6) and (7) are listed positive and negative products of columns (1) and (2), and (1) and (3) respectively.

INERTIA FORCES. The harmonic components of the inertia torque T of the reciprocating masses are all sine curves and are obtained from the following formula, where

W = reciprocating weight, that is, the sum of the weights of piston, piston rod, crosshead and reciprocating end of connecting rod; lb

$\omega = \pi N/30$ = angular velocity, radians per sec

C = constant taken from Table X

$$T = \omega^2 r C W/g \qquad (20)$$

The weights of the reciprocating parts in the high and low pressure cylinders in the units shall be assumed to be 68.6 and 89.7 lb, respectively.

The values of C given in Table X were obtained from "The Range and Severity of Torsional Vibration in Diesel Engines" by F. P. Porter, *Trans. A.S.M.E.*, 1928, and are tabulated for a range of ratios k of connecting rod length to crank radius. For the installation being analyzed, k equals 15/3.5 equals 4.3. Since torque required by the compressor has been taken as positive, the signs of the harmonic components are reversed from those given by F. P. Porter, where the positive direction is that taken for torque developed.

Only the first four harmonics need to be considered since these account for approximately 97 percent of the entire torque.

The resultant harmonic torque is the sum of the components resulting from gas pressure and inertia forces. If M_s is the sum of the corresponding sine terms and M_c is the cosine component resulting from gas pressure only, the resultant harmonic torque M is

$$M = \sqrt{M_s^2 + M_c^2}$$

In adding the separate sine components, attention must be paid to sign. The calculated sine, cosine and inertia components are given in Table IX with their resultants for 8 harmonics.

Vector Diagrams

As a result of the method of loading and unloading, five different operating conditions are obtained for each compressor unit, which consists of two identical 2-stage compressors. These conditions are combinations of three basic cases: No gas load on the cylinders (inertia forces acting only); gas and inertia load on two cylinders and inertia alone on the second pair; and gas and inertia load on all four cylinders. For each harmonic component and for each operating condition a vector diagram can be constructed giving the phase relation between torques of the various cylinders, thus determining the resultant torque.

The sign conventions used to determine the resultant torque vector, Fig. 12, for each compressor unit are as follows. The centerline for cylinder No. 1 is horizontal and is taken as the sine vector axis. Positive sine vectors are taken in a direction opposed to the crank direction and negative values in the crank direction. Positive cosine vectors are taken normal to the crank and 90 deg ahead of it in the direction of rotation, or 90 deg behind the positive sign vector. In constructing the diagram for all four cylinders, the angular phase between cylinder centerlines must be taken into account. The convention used is unimportant provided it is applied consistently.

For the first order, the phase difference between the sine or cosine torque components at successive cylinders is 60 deg. Since each compressor unit consists of two identical compressors, only the resultant vectors need be determined for one high pressure and low pressure cylinder and then place these in proper phase, that is, 60 deg between cylinders No. 2 and 3, and 180 deg between cylinders No. 1 and 4. This procedure holds except when one compressor carries load and the other is unloaded. When operating in this manner the latter has inertia or sine vectors only. The resultant for all four cylinders is then obtained by determining the vectors for each individual cylinder and placing them in their proper phase.

For any other harmonic order, that is, 2, 3, 4 and so on, the component travels at n times the crank speed, where n is the order number. Thus

for the second order, the phase difference between sine or cosine torque components for successive cylinders is 120 deg. For the third order this becomes 180 deg; and so on. Fig. 12 gives the resultant torque vectors, together with phase angles measured from cylinder No. 1 top center, for the various harmonics and operating conditions.

The cranks of the compressor units No. 1 and 2 are 180 deg apart. Consequently, the phase angle between the corresponding resultant vectors of the two units is 180 deg times the harmonic order number, that is, the vectors are in phase for all even numbered orders and counterphased for all odd numbered orders.

The vectors shown in Fig. 12 are for compressor unit No. 1, and are designated M_1. These are used directly in the forced vibration tables, but are modified for proper phase and used for compressor unit No. 2 as M_2. If for any operating condition, the vectors M_1 and M_2 have a phase difference other than 0 or 180 deg, their combined effect for gear torque must be resolved vectorially. Vector solution for 0 or 180 deg is identical with the algebraic solution.

For example, at the bottom of Table VI the torque T_a at the pinion is expressed as a function of M_1 and M_2. Using the fourth order harmonic in Fig. 12 for the third operating condition, that is, compressors 1 and 2 on, 3 and 4 off, the equations are:

(a). $M_1 = 1{,}365 \times \cos 7 \text{ deg} = 1{,}365 \times 0.99255 = 1{,}355$

$M_2 = 83$

Consequently

$T_a = -6.0205 \times 1355 - 0.5981 \times 83 = -8158 - 50 = -8{,}208$ lb in.

(b). $M_1 = 1{,}365 \times \sin 7 \text{ deg} = 1{,}365 \times 0.12187 = 166$

$M_2 = 0$

Therefore

$T_b = -6.0205 \times 166 = -999$ lb in.

and the resultant torque

$T = \sqrt{8{,}208^2 + 999^2}$

$= \sqrt{68{,}369{,}260} = 8{,}268$ lb in.

Because the driving mean torque for this operating condition equals 4,112 lb in., torque reversal will take place. The driving mean torque is calculated as follows:

The torque for 2 compressors, that is, for one unit:

$$\frac{63{,}025 \times 268}{600} = 28{,}150 \text{ lb in.}$$

For the idling unit, friction torque of 10 percent is assumed, consequently the total torque is

$28{,}150 + 2{,}815 = 30{,}965$ lb in.

At the pinion this torque is reduced by the gear ratio so that driving mean torque at the pinion equals

$$\frac{30{,}965}{7.53} = 4{,}112 \text{ lb in.}$$

The torque at the pinion in a revised system, Table VIII, in which a flexible coupling having a stiffness K equal to 0.086×10^6 lb in. per radian is used, for the same operating condition as before when actual torque reversal occurred in the original system, is only 4 lb in., showing the effectiveness of the solution.

In this discussion, matters of purely theoretical interest have been omitted. The author's objective has been to present a practical procedure for applying the theory, and to emphasize the advantages inherent in very flexible couplings in solving cyclic reversing torque problems. By compiling and filing a set of standard forms for reference purposes, the engineer will be able to select quickly data that are appropriate to his particular problem.

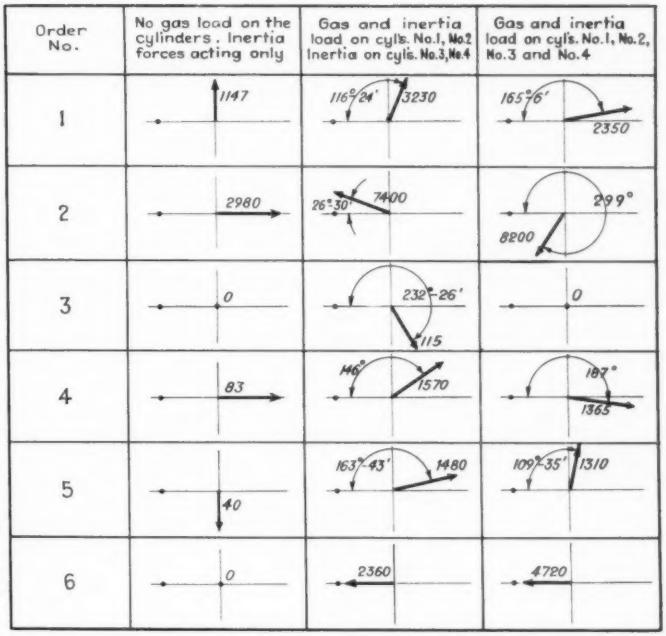

Fig. 12—Phase diagrams and resultant torque vectors at different conditions of loading.

Table X—Constant C for Equation (20)

Order	Sign	Ratio k, $k = l/r$								
		4.0	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8
1	−	0.06351	0.06192	0.06038	0.05894	0.05757	0.05626	0.05500	0.05380	0.05266
2	+	0.50012	0.50011	0.50010	0.50009	0.50008	0.50008	0.50007	0.50006	0.50006
3	+	0.19217	0.18718	0.18246	0.17804	0.17385	0.16973	0.16601	0.16234	0.15886
4	+	0.01613	0.01532	0.01458	0.01389	0.01325	0.01265	0.01200	0.01159	0.01110
5	−	0.00258	0.00239	0.00222	0.00206	0.00193	0.00180	0.00167	0.00157	0.00148
6	−	0.00014	0.00013	0.00012	0.00010	0.00009	0.00009	0.00008	0.00007	0.00007

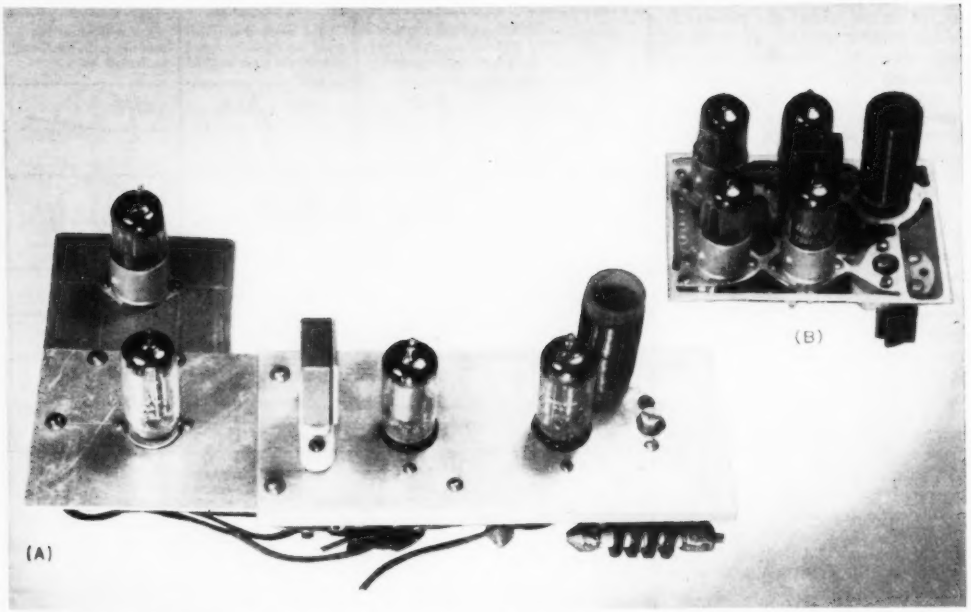

Fig. 1—Breadboard assembly (A) represents electrical engineer's working model of an electronic device. (B) Production version of same equipment is the result of the design engineer's application of special shielding, wiring and mounting techniques.

Mechanical Aspects of Electronic

- Shielding techniques
- Wiring methods
- Grounding practices
- Use of sub-assemblies
- Mounting of controls

DESIGN ENGINEERS are frequently called upon to adapt the electronic engineer's breadboard model of a control circuit to meet specific space and assembly requirements. This calls for an understanding of certain circuit functions and characteristics, for often the length of lead wires or the placement of components influences the performance of the equipment. The proper use of shielding, method of wiring, connection of grounds and mounting of parts not only helps the designer obtain optimum performance, but also fills production requirements.

When the electronic engineer is satisfied with the functioning of a circuit, the breadboard model, as shown in Fig. 1 (lower view), is turned over to the designer. The questions usually asked are: How close together can the various components be assembled without producing undesirable electrostatic or magnetic interference? What thickness of shielding material is needed to minimize coupling between components? Can one or more subassemblies be used? Where should parts be grounded? After obtaining the answers to these and many other questions from the electronic engineer, the designer can proceed with the task of arranging components, choosing shields, connecting the grounding wires. The final result is shown in Fig. 1, upper view.

Shielding

Shielding of components and wires from electrostatic and magnetic fields is not always required, especially when components are far removed from interfering fields. However, this is not usually possible and often even lead wires several inches in length require shielding. This problem is particularly prevalent of wiring in vacuum tube circuits that precede amplifiers of high voltage sensitivity. For example, the volume control of a coin operated phonograph amplifier may be in the grid circuit of the first amplifier tube. Any attempt to locate the volume control at an appreciable distance from the amplifier, with unshielded lead wires, would result in noticeable hum in the loudspeaker. The hum is a result of a voltage being induced in volume control leads from the alternating current power line and multiplied in the amplifier. The use of commercially available shielded wire to connect the amplifier to the control would permit remote operation. Two general rules can be observed from this example. (1) In equipment incorporating electronic amplifiers, the higher the voltage sensitivity of the amplifiers, the greater will be the need for shielding. (2) High-impedance circuits, such as the grid circuit of a vacuum tube, should be protected from induced interference, and the length of the grid and plate leads should be short or shielded if their length exceeds several inches.

Another source of difficulty in the design of amplifiers is interaction between transformers, usually between the power and the input or amplifying

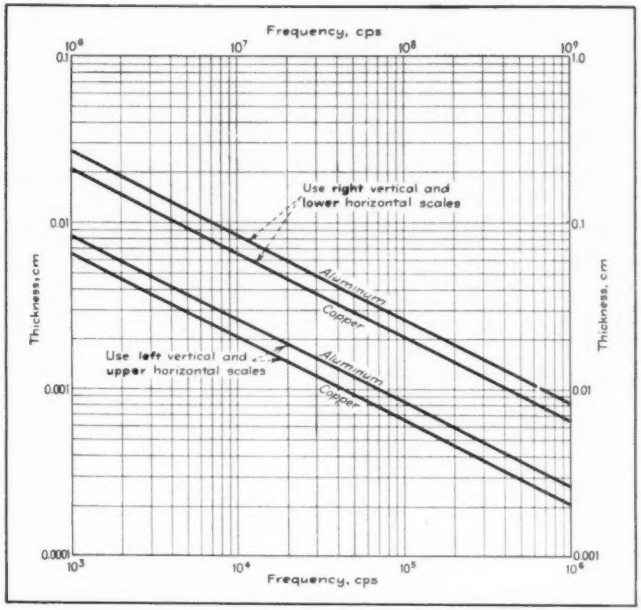

Fig. 2—Minimum shield thickness for conducting magnetic shields of aluminum and copper at audio and radio frequencies is obtained from appropriate pair of scales.

Assemblies

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tube transformers. Here again the stray magnetic field of the power transformer induces a voltage in the coil of the second transformer by virtue of the magnetic core. The power transformer should be located as far from the input component as possible. To minimize induction, it is usually best to locate the cores of other transformers at right angles to the power transformer. Since the disturbing field diminishes inversely as the cube of the distance between elements, the spacing is therefore a prime factor. Shielded interstage and input transformers are available with ferrous jackets at a slightly greater cost than the open type.

The effectiveness of shielding around a component inclosed in a box or cylinder is dependent on the initial permeability of the shielding metal. The material of higher magnetic permeability will offer greater protection because stray flux will occupy the low reluctance path through the shield. Cast iron, therefore, is not as suitable as any one of the many high-permeability alloys.

Magnetic shielding with direct current or at audio frequencies can be illustrated by taking the ratio of the magnetic field without shielding to the magnetic field in the presence of shielding. This relationship is shown in the equation:

$$\frac{\text{Field (no shielding)}}{\text{Field (shielding)}} = 0.22\mu\left[1-\left(1-\frac{t}{r}\right)^3\right]$$

where

μ = initial permeability of shield
r = radius of sphere inclosing the same volume as the outer surface of the shield
t = thickness of shield

note: t and r to be taken in the same units—in. or cm.

It is more economical to utilize several thin concentric shields rather than one relatively thick one where a high degree of shielding is required. Additional shielding can be had by inserting a thin copper shield between two concentric magnetic shields. The degree of shielding obtained with multiple magnetic shields increases as the permeability of the material raised to the power corresponding to the number of concentric shields. The reflected effect on the parameters of the shielded component resulting from the addition of shielding is usually small with low-frequency components and therefore does not affect the circuit performance. This rule does not hold with radio frequency shielding and therefore consideration must be given to this factor.

Many electronic control devices and instruments incorporate radio frequency oscillators or signal generators for measurement and control. The oscillator must usually be shielded to prevent interfering radiation, to avoid undesirable coupling and to minimize instability caused by changes in capacity from nearby objects. Conducting shields of aluminum or copper should be used. Shielding that is near a radio frequency coil or transformer may interfere with proper functioning of the circuit if adequate consideration is not given to the following simple detail. The effectiveness of shielding depends upon the creation of eddy currents in the shield material. The energy involved in setting up these currents is derived from the field of the coil, and therefore the effective resistance of the coil is raised. To maintain a fair balance between space requirements and the loss caused by this resistance, the general rule is to place the shield at a distance equal to the radius of the coil at all points from the coil windings.

A graph showing the depth of penetration of these currents in aluminum or copper shielding is given in Fig. 2. By spotting the frequency at which shielding is to be effective, the minimum thickness of a shield can be determined. The thickness value obtained should be multiplied by a factor of at least two and preferably four to allow for variations in the resistivity and temperature of the metal. If thicker shielding is required for reasons of structural stability, the gain in effective shielding is of little value for improving electrical performance.

Wiring

In designing an electronic assembly for production wiring, the engineer has four assembly methods from which to choose. These are: (1) Forming the wires into a cable that is inserted in the assembled chassis; (2) adding a few wires at each assembly position, as in a conveyor line; (3) following a schematic or pictorial diagram; (4) printing circuits.

The designer must consider which method of wiring is best for the job. Each method has its economic considerations, but often the type and functioning of the circuit will dictate one particular method. For example,

Recommended Shielding, Wiring and Grounding Practice for Electronic Equipment

Type of Equipment	Frequency	Shielding	Wiring	Grounding	Remarks
Air Conditioning Control:					
Temperature			Cable	Chassis	Thermocouple leads may have to be shielded to avoid stray fields
Humidity			Cable	Chassis	
Aircraft—control	Supply frequency, 400 cps or d-c		Cable	Chassis	Avoid heavy shielding. The higher the supply frequency, the less the shielding required.
Amplifiers:					
D-c	D-c	Magnetic	Cable	Chassis	No shielding required except to keep out stray fields.
Audio	10 to 20,000 cps	Magnetic	Cable	Chassis	
Ultrasonic and video	20 kc to 5 mc	Magnetic and nonmagnetic	Point-to-point	Bus or single point	Mount components on low-loss, nonconducting chassis to avoid circulating currents.
Radio	0.5 mc and above	Aluminum or copper	Point-to-point	Single point	
Hearing Aids	Audio	None	Point-to-point or printed circuit	Any	
Induction Heaters	Radio	Al or Cu	Cable and point-to-point	Single point	Power loss caused by circulating currents in cabinet must be avoided. Care should be taken when grounding equipment to earth.
Instruments, testing:					
Analyzers (voltmeters, ammeters, ohmeters)	D-c	None	Cable	Single point preferable; chassis	
Bridges:					
D-c	D-c	None	Point-to-point	Single point	Extraneous fields must be kept out and effects of outside capacitance minimized.
A.F.	Audio	Magnetic	Point-to-point	Single point	
R.F.	Radio	Al or Cu	Point-to-point	Single point	
Oscillators	Audio	Magnetic	Cable	Chassis	
	Radio	Al or Cu	Point-to-point	Single point	Case must be shielded to prevent unwanted radiation and minimize the effects of external capacitance.
Photo-Electric Control	D-c		Cable	Chassis	
Power Supplies:					
Copper oxide-selenium	25–400 cps	None	Cable	Chassis	Transformers should be shielded to limit magnetic field if operated in vicinity of other equipment.
Vacuum and gas tube		None	Cable	Chassis	Allow sufficient ventilation for tubes.
Voltage regulators		None	Cable	Chassis	
Vibrators	25–200 cps	Nonmagnetic and magnetic	Cable	Chassis	Shield to prevent radiation caused by sparking at contacts.
Receivers—radio:					
Portable		Al	Point-to-point or printed circuit	Chassis	
Home		Al or Cu and magnetic	Point-to-point	Chassis	
Communications		Al or Cu and magnetic	Point-to-point and cable	Single point and chassis	
Recorders and Meters		Magnetic			Mount in magnetic container to avoid effect of extraneous fields.
Timing and Welding Controls		None	Cable	Chassis	

the wiring of the components in high frequency oscillators cannot successfully be accomplished by the cabling method, because the closely-packed wires introduce considerable distributed capacitance and inductance. For most low-frequency circuits and those conducting direct current, the cabling method is economical and time saving.

This method consists of scaling on a wooden board the locations of tube socket terminals and other components. Resistors and capacitors can usually be mounted on terminal strips and strategically lined up with the tube sockets or components to which they are connected. By a study of the circuit diagram, a plan is then made of the path along which the main body of wires will follow. With the circuit diagram in view, color-coded wires are placed in channels formed by nails or pegs. Each wire is made sufficiently long to permit convenient soldering to components when the cable is complete. After the wires are tied in cable form with waxed lacing cord and, in some applications, treated with preservative lacquers, the completed cable is placed on the assembly and the ends soldered to the various terminals according to the established color code. Fig. 3 shows the completed assembly.

This method of wiring is extremely useful where large amounts of wiring are needed as in switchboards, power supplies and relay control systems. A combination of cabling and direct point-to-point wiring is useful for equipment such as amplifiers, radio receivers and transmitters. The conveyor system technique or point-to-point wiring is used primarily for low-cost production of household radio receivers or similar highly competitive electronic equipment. The wiring of a complete system by one individual, for quantity production, is limited to applications that require special skill or a limited amount of handling, as with precision instruments. Printed circuits are being used to save both space and weight.

Grounding

In many applications it is possible to reduce the amount of wiring by using the metal chassis of the equipment as a common ground connection. All components that are in the ground circuit can be connected directly to the chassis by means of soldering or a lug fastened under a bolt head. For small assemblies, such as Radiosonde transmitters, a copper chassis is used and the ground leads soldered directly to the chassis. There are, however, certain precautions that must be taken with regard to chassis grounds.

When parallel resonant (tuning)

circuits incorporate coils and condensers, it is customary that one side of the coil and condenser go to the electrical ground potential. It is undesirable to ground the coil and condenser separately to the chassis, each at its own location. Preferred procedure is to connect a wire directly from the coil to the condenser and use one ground connection at the closest point to the chassis. This procedure is followed to avoid the flow in the chassis of tuned-circuit currents that might interfere with similar currents radiated from another tuned circuit.

Similarly, grounding to the chassis of components in which different levels of potential exist can lead to intercircuit coupling. In instances such as these, it is frequently advisable to use a common bus-bar type of ground as shown in Fig. 4 below.

In high frequency and oscillator circuits, it is preferable to apply all the components to be connected to electrical ground at a common mechanical ground point to avoid circulating currents. Grounding high frequency equipment, such as induction heaters, is somewhat difficult because of high current intensities.

Sub-Assemblies

In many instances, the use of a subchassis as a mount for several circuit components, such as the resistors and small capacitors shown in Fig. 3, will result in simplified wiring and a saving of space. By mounting the components directly to solder lugs on the sub-assembly and maintaining a good physical support, the effects of vibration in the equipment are minimized.

In many circuits, the effect of a slight movement among the components or the wiring cannot be tolerated because a change in the distributed capacitance of the circuit is developed. The capacitance between two conductors separated by a dielectric or insulating material is inversely proportional to the spacing. Consequently, any movement of a wire will cause a change in capacitance in its circuit. In radio frequency circuits, particularly oscillators, this capacitance change is to be avoided.

Mounting and Location of Controls

In planning the electrical layout, some thought must be given to the final position of knobs and meters. For example, the shaft of a turning condenser usually cannot be moved very far once the location of its operating circuit has been determined. Therefore, if the position of the shaft is not suitable for a particular panel design, some mechanical linkage such as a flexible shaft, gear train or dial cable must be used.

Standardized insulating-shaft couplings and flexible couplings provide a satisfactory means for insulating the control shaft and permit operation from the desired panel location. Flexible shafts can be adapted to permit control operation when the component shaft is at 90 deg to the panel.

Radio frequency circuit components that require front panel controls usually cannot be moved very far. On the other hand, rheostats and potentiometers controlling direct currents or audio frequencies can be located in the most strategic positions, provided shielding is introduced when large amounts of amplification follow the circuit in which control is operating.

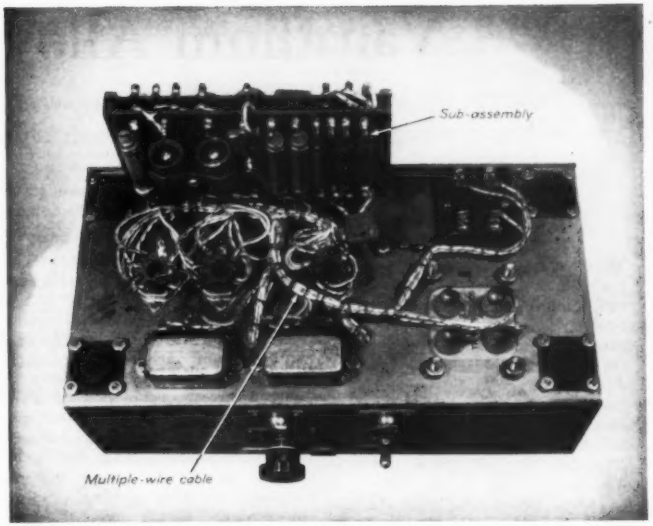

Fig. 3—Wiring by the cable method simplifies assembly. Sub-assembly (upper left) provides central mounting for small parts that do not require shielding.

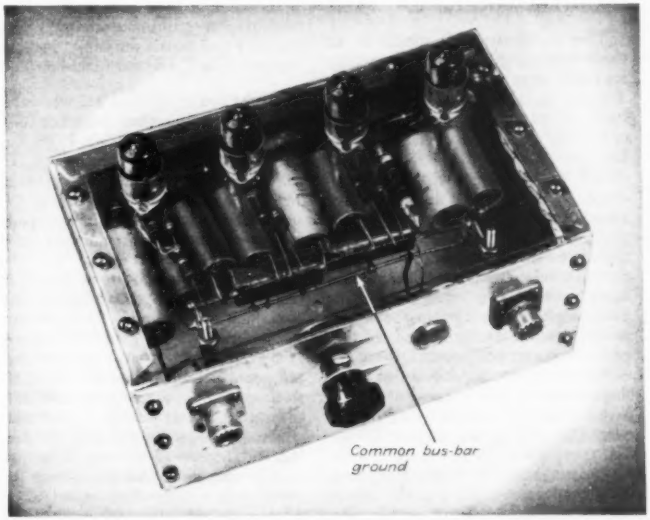

Fig. 4—Bus-bar grounding is recommended when different levels of potential are apt to cause intercircuit coupling.

Vanadium Alloy Steels

Properties and applications of the principle types of vanadium-containing steels, including forging steels, casting steels, spring steels, carburizing steels, and plate steels

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WHEN VANADIUM STEELS were first made in commercial quantities, the vanadium appeared to perform three essential functions: By combining with gases in the molten metal, it improved the quality of the steel; by refining the size of the grain, it increased the toughness of the steel; and finally, it acted as an alloying element that considerably improved the mechanical properties of plain carbon and alloy steels.

Today, steelmaking methods have improved, and high quality steels can be made by other and cheaper methods. But in many cases, grain refinement and improved mechanical properties still can be obtained only by the addition of vanadium. The steels in which vanadium is used for these or other purposes can be broken down into six classifications: Forging steels, carburizing steels, plate steels, spring steels, cast steels and tool steels. Since the steels in the last group are of special composition and for specialized application, they will not be further discussed.

Forging Steels

This classification is meant to include everything from small drop forgings and large forgings made in open dies to parts machined from rolled bars, except for those parts that are carburized. (Carburized parts also contain some vanadium, but will be discussed later under a separate classification.) In these steels the presence of vanadium is responsible for a fine grained, tough structure that is relatively insensitive to cracking during hot working operations; an endurance limit, especially in manganese-vanadium steels, that is high in proportion to the tensile strength; and an improved resistance to impact.

There are four major types of vanadium forging steels, each of which includes several variations in composition. These are shown in Table I.

CARBON-VANADIUM STEEL has many of the advantages of a plain carbon steel—ease of fabrication and simplicity of heat treatment—but has mechanical properties appreciably better. Other steels having equal strength require more complicated heat treatments and more care during processing.

MANGANESE - VANADIUM STEEL, if normalized and tempered, has a better combination of strength and ductility than carbon-vanadium steel. This illustrates one of the most important characteristics of vanadium - containing steels: Appreciable hardening of a low carbon forging steel in a comparatively large section size can be obtained with a moderate cooling rate. Although this same strength range can be obtained with steels having moderate amounts of other alloying elements, quenching is usually necessary. While there is nothing fundamentally wrong with quenching a large forging, it is something which many manufacturers are glad to avoid for simplicity's sake.

CHROMIUM - VANADIUM STEEL is usually used as a forging steel for large section sizes by the railroads and by manufacturers of heavy equipment. A great many parts in both the automotive and aircraft industries also are made of this type, either forged or rolled, and in most cases, oil quenched. It has a high hardening capacity on quenching and good wear resistance, in addition to a high proportional limit with respect to ultimate strength, good ductility and impact resistance, and low distortion and good machinability.

NORMALLOY STEEL has a lower vanadium composition than the other forging steels. It is used when high ductility with moderate strength is required with only a normalizing treatment. It does not distort after this normalizing treatment, which property is of value in making precision parts such as crankshafts.

The other compositions listed in Table I contain molybdenum and vanadium in addition to chromium or nickel, and are used to obtain greater strength in large sections that are quenched and tempered. In these steels, vanadium serves to increase ductility and impact resistance, decrease sensitivity to cracking during quenching, and increase resistance to softening during tempering, thus permitting the use of higher tempering temperatures. Also, vanadium helps retain the properties and dimensions of forgings used at elevated temperatures, such as rotor forgings. This fact becomes more important with increased interest in elevated temperature properties of steels.

Carburizing Steels

Vanadium so controls grain size and toughness that most vanadium carburizing steels are quenched directly from the carburizing temperature. Metallurgically, this is a drastic treatment because the grain structure of most steels is too coarse at the carburizing temperature to impart satisfactory ductility and impact strength to the steel. As a result, it often is necessary to slow cool other steels after carburizing, and to reheat and quench them twice to obtain the optimum properties in both the case and the core, with a consequent increase in heat-treating cost.

Vanadium also imparts several other properties to carburizing steel. First, it limits the amount of austenite that is retained in the case after a normal carburizing cycle; as the amount of austenite decreases, the wear resistance and hardness of the case increases. It is generally recognized that, as the alloy content of a steel increases, the amount of retained austenite in the case also increases; this tendency is counteracted to some extent by the presence of vanadium.

Second, the combination of elements in chromium-vanadium steel favors the diffusion of carbon throughout the steel. Third, the wear resistance of a carburized part appears to depend to some extent on the form of the carbides in the carburized surface; the most desirable form is spherical, and direct-quenched chromium - vanadium steels contain such carbides in their cases. And lastly, a low rate of drop in carbon content from the case to the core of these steels insures an excellent bond between the case and core.

Of the other steels listed in Table II carbon-vanadium steel is used for gears in which high core hardness, uniformity of case depth, and moderate resistance to impact is required. Manganese-vanadium steel possesses high ductility and impact strength with moderate core strength. Normalloy is a lower alloy steel having good properties and a fast carburizing rate. Manganese - chromium - vanadium, chromium-nickel-vanadium, and nickel-molybdenum-vanadium steels have a higher alloy content which in large

Table I—Vanadium-Containing Forging Steels

Vanadium Forging Steels				Typical Tensile Properties of a Steel in This Range[1]						
Type	Composition, percent	Typical Heat Treatment[2]	Representative Applications	Size and Shape	Heat Treatment[2]	Yield Point, psi	Tensile Strength, psi	El. in 2 in, percent	Red. in Area, percent	Izod Impact, ft lb
C-V	C 0.45–0.55 Mn 0.60–0.90 Si 0.20–0.35 V 0.15 min.	Usually—N + T Often—DN + T (for max. toughness) Sometimes—Q + T	Locomotive axles, crankpins, piston rods, pump shafts; power plant forgings; axles, oil well bits; large gears and pinions	Axle (8 in. dia) Crankpin (10 in. dia) 1 in. round 1 in. round	N + T N + T N WQ + T	60,300 61,300 86,500 120,000	95,050 92,850 118,300 127,300	28.5 29.0 21.6 21.0	52.2 53.0 50.2 58.2	18 19 22 68
Cr-V	C 0.25–0.55 Mn 0.50–0.80 Si 0.15–0.30 Cr 0.80–1.10 V 0.15 min.	For heavy sections—N + T or N + Q + T For light sections N + Q + T or N	Oil well bits, drill bodies, shafting; electrical armature shafts, rotor shafts; hydraulic piston rods; forging die blocks; forming tools.	12 in.–14 in. axles 8 in. crankpins 1 in. round	DN + T Q + T N + Q + T	67–72,000 87,800 132–169,000	98–108,000 126,550 138–176,000	24.5–23.5 20.0 22–16	47.5–44.0 54.9 66–52	 82
Cr-V	C 0.35–0.45 Mn 0.90–1.20 Si 0.10–0.30 Cr 1.00–1.25 V 0.15 min.	Q + T	Shafting; crankshafts; die blocks and piston rods for forging equipment; oil well drills and equipment; gears; pinions.	Up to 2 in. dia 2 in.–4 in. 4 in.–6 in. 6 in.–8 in.		120,000 128,000 128,000 115,000	130,000 145,000 153,000 140,000	20.0 18.0 17.0 17.0	60.0 52.0 47.0 47.0	....
Mn-V	C 0.18 max. Mn 1.45 max. Si 0.15–0.30 V 0.08–0.14	Usually—in as forged condition Sometimes—A or N	Locomotive valve motion parts; airframe components.	2 in. x 2 in. 2 in. x 2 in.	None After local heating	63,500 63,000	86,500 81,000	28.0 24.0	70.0 69.0	19 95
Mn-V	C 0.27–0.34 Mn 1.45–1.75 Si 0.20–0.35 V 0.15 min.	N + T or Q + T	Locomotive main rods, side rods, crank pins, piston rods, cross heads, driving axles and piston heads.	Main rod Main crankpin Driving axle	N + T N + T N + T	75,140 74,000 70,000	101,700 103,000 96,500	28.0 26.0 28.0	62.4 61.5 60.0	....
Mn-Mo-V	C 0.22–0.30 Mn 1.30–1.60 Si 0.15–0.35 Mo 0.20–0.30 V 0.15–0.20	N + T or Q + T		4 in. x 4 in. 4 in. x 4 in.	N + T WQ + T	81,900 92,700	101,700 107,000	25.0 22.5	64.0 63.3	70 79
Normalloy	C 0.15–0.50 Mn 1.00–1.60 Si 0.15–0.30 Cr 0.30–0.65 V 0.06–0.12	Usually—N or Q + T Sometimes—N + T	Automotive axle shafts, steering knuckles, crankshafts; oil well sucker rods; rotor forgings.	1 in. round[3] 1 in. round[3] 1 in. round[4] 1 in. round[4]	N NQ + T N WQ + T	64,500 114,600 79,200 136,800	89,800 125,000 112,000 143,000	29 20 27 18	68.0 64.0 62.0 56.0	65 73 65
Ni-Mo-V	C 0.22–0.33 Mn 0.50–0.80 Si 0.20–0.35 Ni 2.25–2.75 Mo 0.15–0.35 V 0.15 min.	N + T or Q + T	Large rotor shafts for turbines and generators; crankshafts; large ring gears.	12 in. dia 13 in. dia 30½ in. dia	N + T N + T N + T	94,000 89,000 81,500	115,000 109,000 105,000	23.0 21.0 18.5	57.3 58.6 46.3	....
Cr-Mo-V	C 0.35–0.45 Mn 0.50–0.90 Si 0.20–0.35 Cr 0.80–1.50 Mo 0.30–0.60 V 0.12–0.25	Usually—OQ + T Sometimes—N + T	Hot forming tools; electrical rotor shafts and armature shafts; shafting for large equipment; oil well drill bits; bolts for elevated temperature service.	6 in. dia 6 in. dia	N + OQ + 1200FT N + OQ + 1100FT	121,100 137,400	138,000 164,000	19.0 17.0	59.4 56.2	45 16
Ni-Cr-Mo-V	C 0.20–0.50 Mn 0.60–1.25 Si 0.20–0.35 Cr 0.50–2.50 Mo 0.20–0.50 V 0.08–0.25	Usually—OQ + T Sometimes—N + T	Die blocks and piston rods for forging equipment	5½ in. dia 7½ in. dia 9 in. dia	O + T O + T Q + T	129,500 128,250 116,500	146,750 146,000 143,750	20.0 19.0 18.0	59.1 57.5 58.8	56 52 58
Mo-V	C 0.40–0.50 Mn 0.60–0.90 Si 0.15–0.30 Mo 0.25–0.40 V 0.15–0.25	Usually—Q + T	Bolts, gears, small dies.	1 in. round	N + WQ + T	122,000	147,000	20.5	59.0	74

[1] The tensile properties given are for a steel of a specific composition, and are not necessarily representative of steels having larger or smaller amounts of carbon or other elements.
[2] Symbols given under the columns on heat treatment have the following meanings: N—Normalize; DN—Double Normalize; T—Temper; Q—Quench WQ—Water Quench; OQ—Oil Quench; A—Anneal.
[3] For steel having 0.25C and 1.20 Mn
[4] For steel having 0.41C and 1.19 Mn.

parts, permits hardening of the core with a minimum of warping.

The chromium-vanadium steel AISI-A 6120 in the table is a recent modification of ASTM 6120 steel. The mangansese content has been raised and the chromium and vanadium ranges lowered slightly. This change has resulted in greater hardness without an appreciable change in toughness or other characteristics. This steel also is somewhat lower in cost.

Plate Steels

In the fabrication of structures from rolled plate steel, perhaps the most important properties required in the steel are ductility and freedom from hardening during cold working or after heating. This is particularly true if the plates are to be welded. Most alloys that are added to plate steels to increase strength also increase the tendency of the steel to harden adjacent to a welded joint. Also, the high welding temperatures coarsen the grain. When vanadium is present in an amount greater than 0.08 per cent, it increases the strength, if the steel is cooled at a moderate rate, and at the same time deters the formation of martensite, which tends to form with faster cooling rates. In other words, it acts to benefit the useful strength while guarding against hardening, which might occur after welding. In addition it prevents the formation of a coarse grain structure both in the fused weld metal and in the adjacent parent metal.

Manganese vanadium plate steel is the most widely used of the types shown in Table III. Besides good weldability, its outstanding characteristics are its retention of strength at elevated temperatures, its freedom from embrittlement, and its ability to be cold formed without excessive hardening and loss of ductility. The yield and

Table II—Vanadium-Containing Carburizing Steels

Vanadium Carburizing Steels				Typical Tensile Properties of a Steel in This Range [1]						
Type	Composition, percent	Typical Heat Treatment	Representative Applications	Heat Treatment	Yield Point, psi	Tensile Strength, psi	El. in 2 in., percent	Red. in Area, percent	Brinell Hardness	Izod Impact, ft lb
C–V	C 0.25–0.35 Mn 0.60–0.90 Si 0.15–0.30 V 0.04–0.08	Carburize, pot cool, oil quench, temper	Gears with high core hardness	Pot OQ + T	172,800	234,750	6.0	12.6		9.3
				Pot OQ + OQ + T	86,400	125,850	18.0	47.5		49.3
				Pot Cool + WQ + T	175,800	207,050	9.0	18.4		8.3
				Pot Cool + OQ + T	69,950	110,900	21.0	53.8		55
Mn–V	C 0.10–0.15 Mn 1.60–1.90 Si 0.15–0.30 V 0.15 min.	Carburize, pot quench, requench in oil, temper	Gears	Pot OQ + OQ + T	53,100	98,650	35.5	70.3		105
Cr–V (AISI A-6120)	C 0.17–0.22 Mn 0.70–0.90 Si 0.20–0.35 Cr 0.70–0.90 V 0.10 min.	Carburize, pot quench, temper	Gears and shafts; piston pin bushings	Pot OQ + OQ + T	102,750	131,750	15.5	42.8	282	63
Cr–V (ASTM 6120)	C 0.15–0.25 Mn 0.30–0.60 Cr 0.80–1.10 V 0.15 min.	Carburize, pot quench, temper	Automobile and aircraft engine gears, camshafts, and piston pins	Pot OQ + OQ + T	97,000	126,050	15.0	48.2	271	65
Mn–Cr–V	C 0.10–0.15 Mn 1.60–1.90 Si 0.15–0.30 Cr 0.40–0.60 V 0.15 min.	Carburize, pot cool, oil quench, temper	Gears	Pot OQ + OQ + T	97,550	135,000	21.0	56.8	255	54
Normalloy	C 0.15–0.20 Mn 1.00–1.30 Si 0.15–0.30 Cr 0.30–0.65 V 0.06–0.12	Carburize, pot cool, water, quench, temper	Small parts with thin cases	Pot OQ + OQ + T	98,650	138,650	23.5	47.5	279	19
Cr–Ni–V	C 0.12–0.17 Mn 0.30–0.50 Ni 0.40–0.60 Cr 0.45–0.75 V 0.12–0.18	Carburize, pot cool, water quench, temper	Automotive ring gears	Pot cool + WQ + T	52,650	99,700	22.8	42.8		35
				Pot cool + OQ + WQ + T	47,800	86,300	29.5	60.8		60.8
Ni–Mo–V	C 0.08–0.15 Mn 0.30–0.60 Si 0.15–0.30 Ni 3.25–3.75 Mo 0.25–0.35 V 0.10–0.15	Carburize, pot cool, oil quench, temper	Gears and shafts	Pot quench + T	95,850	114,600	18.0	60.3	243	77.5

[1] The tensile properties given represent average core properties of approximately 1.0 in. round bars of typical steels within the composition range shown.
[2] Symbols given under the columns on heat treatment have the following meanings: OQ—Oil Quench; WQ—Water Quench; T—Temper.

Table III—Vanadium-Containing Plate Steels

Vanadium Plate Steels				Typica lTensile Properties of a Steel in This Range[1]					
Type	Composition, Percent	Typical Heat Treatment	Representative Applications	Size and Shape	Yield Point, psi	Tensile Strength, psi	El. in 2 in., percent	Red. in Area, percent	Izod Impact, ft lb
C–V	C 0.12–0.18 Mn 0.50–0.80 Si 0.10–0.30 V 0.15 min.	Usually—as rolled Sometimes—Normalized or annealed	Pressure vessels of light section	Plate, 1.0 in.	Room Temp. 42,650 200F 40,000 400F 38,800 600F 31,300 800F 30,200	58,300	25	55	....
Cr–V	C 0.10–0.30 Mn 0.30–0.60 Si 0.15–0.30 Cr 0.80–1.10 V 0.15 min	As rolled plus stress relieve or anneal	Welded pressure vessels	¾ in plate, hot rolled	57,200	77,900	20.6	39.5	57.1
				¾ in. plate, hot rolled	55,250	82,900	17.5	42.0	55.9
Mn–V	C 0.18 max Mn 1.45 max Si 0.15–0.30 V 0.80–0.14	Usually—as rolled Sometimes—stress relieved or annealed	Locomotive boiler and fire-box plate; ship plate	½ in. plate,	61,950	75,650	26.8	62.3	....
				¾ in. plate,	59,200	82,400	26.0	66.3	....
Mn–V–Ti	C 0.18 max Mn 1.30 max Si 0.15–0.30 V 0.05 max Ti 0.005 min	Usually—as rolled Sometimes—stress relieved or annealed	Ship plate	¾ in. plate, hot rolled	56,200	73,500	26.2	58.0	....
Mn–Mo–V	C 0.10–0.20 Mn 1.00–2.00 Si 0.15–0.30 Mo 0.20–0.35 V 0.10–0.15	Usually—as rolled Often—stress relieved or annealed or normalized	High strength boiler plate	1 in. plate, hot rolled	75,500	95,200	20.8	....	....
Ni–Cr–Mo–V	C 0.10–0.20 Mn 0.80–1.20 Si 0.20–0.35 Ni 0.75–3.00 Cr 0.80–1.10 Mo 0.40–0.60 V 0.08–0.15	Often—normalized and tempered Often—quenched and tempered	High strength plate-steel for oil refining, chemical and power plant application	1 in. plate, normalized and tempered	76,500	98,400	23.2	59.0	....

[1] The tensile properties shown represent typical steels within the composition range given, but are not meant to be either average or minimum values.

tensile strength drop slowly and uniformly as temperature increases. At 1,200 F. the strength is higher than that of other steels having an equivalent strength at room temperature. Neither in the strength nor in the ductility at elevated temperatures are the usual embrittlement ranges found. When one considers that a locomotive boiler passes through at least one of these embrittling ranges several times a day, the chances of cracking at points of high stress would seem much greater with a steel which exhibits this embrittlement. Extensive testing of cold worked samples of this steel both before and after heating, has shown that there is less hardening and loss of impact strength than in equivalent steels.

When other alloying elements are present, as in the chromium-vanadium steel and the manganese-molybdenum-vanadium steel, some of the insensitivity to mechanical and thermal abuse is sacrificed for greater strength and wear resistance. In this class of plate steels, however, vanadium exerts the same influence on mechanical properties.

Spring Steels

Two properties make chromium vanadium steel suitable for springs: A high true elastic limit, and an ability to withstand fatigue and shock. The higher elastic limit of chromium-vanadium steel permits increasing the mean static stress to 105,000 to 110,000 pounds per square inch as against 85,000 to 90,000 psi allowed for carbon steel in equivalent applications. For semi-elliptic locomotive springs, a mean static stress of 80,000 to 85,000 psi is permissible as against 65,000 to 70,000 psi for carbon steel. This steel retains its resiliency at elevated temperatures up to about 750 F., such as are encountered in Diesel engine valve springs.

Silicon-vanadium steel springs have been successfully applied in large helical springs such as those used in the trucks of railway cars and locomotives. It has the necessary high strength and toughness, and, unlike most alloy steels, does not become fibrous when heat-treated nor crack when quenched in sizes over one-half inch in diameter. With this material, helical springs can be designed with a maximum fibre stress of 110,000 to 115,000 psi as against 90,000 to 100,000 psi for plain carbon steel, and for a mean static stress of 70,000 to 75,000 psi as against 60,000 to 65,000 psi for carbon steel. This steel also possesses free-scaling qualities. Minor surface imperfections, common to all steels, are removed during hot-working at the mill, thus making possible bars and finished springs with a good surface condition.

A new group of carbon-vanadium spring steels has recently been developed, having the compositions shown in Table IV. These steels may be hardened effectively in sections up to about one inch in diameter or thickness, or may be hardened to a uniform depth. Good toughness and resistance to impact are obtained in either instance. They are applicable for automotive leaf and coil springs having hardnesses up to about 450, and in some cases, up to 475, Brinell, the exact hardness depending upon the design and on the thickness or diameter.

Although chromium-vanadium steel functions successfully in the form of helical valve springs of internal combustion engines, steam valves, and similar applications, there are some applications that require springs of high creep resistance at temperatures higher than those for which chromium-vanadium steel is suited. For such uses, the last four steels listed in Table IV are best adapted.

Cast Steels

The influence of vanadium upon the structure and properties of cast steel is first observed in the "as cast" condition. A steel containing vanadium will show less dendritic segregation and greater freedom from Widmanstätten patterns within the grains than a vanadium-free steel, if the balance of the compositions and the steel-making practices are alike. It is obvious that this more even distribution of macro- and micro-constituents in the as-cast condition improves the uni-

Table IV—Vanadium-Containing Spring Steels

Steel		Typical Heat Treatment[1]	Properties and Applications
Type	Composition, percent		
Cr–V	C 0.45–0.55 Mn 0.50–0.80 Cr 0.80–1.10 V 0.15–0.20	Usually—OQ+T Sometimes—cold drawn or cold drawn+OQ+T	High true elastic limit and good resistance to shock and fatigue. Especially applicable for helical and elliptical springs that must withstand severe loading conditions, such as semi-elliptical locomotive springs. Permits using a mean static stress of 105,000 to 110,000 psi as compared with 85,000 to 90,000 psi for plain carbon steel. Can be used at temperatures up to about 750 F without serious loss of resiliency. Properties of a typical steel in this group as follows: Yield point, 165,000 to 210,000 psi; tensile strength, 175,000 to 230,000 psi; elongation in 2 in., 10–14 percent; reduction in area, 30–45 percent; Brinell hardness, 360 to 460.
Cr–V	C 0.48–0.55 Mn 0.70–0.90 Si 0.20–0.35 Cr 0.80–1.10 V 0.10 min.	Usually—OQ+T Sometimes—cold drawn or cold drawn+OQ+T	
Cr–V	C 0.55–0.65 Mn 0.50–0.80 Cr 0.80–1.10 V 0.15–0.20	Usually—OQ+ Sometimes—cold drawn or cold drawn+OQ+T	
Si–V	C 0.60–1.00 Mn 0.45–0.65 Si 0.50–0.75 V 0.15–0.20	Small sizes—cold drawn+anneal Large sizes—OQ+T	Has free scaling qualities, and does not become fibrous on heat treatment. Fiber stress of 110,000–115,000 psi can be used during design. Used for large helical springs. Properties of a typical steel in this group are as follows: Yield point, 175,000–200,000 psi; tensile strength, 195,000–220,000 psi; elongation in 2 in., 8 to 10 percent; reduction in area, 20 to 30 percent; Brinell hardness, 380 to 444.
C–V	C 0.65–0.75 Mn 0.85–1.05 Si 0.50–0.75 V 0.15–0.20	Usually—OQ+T	May be hardened in sections up to one in. in dia. Good hardness and resistance to impact. Used for automotive leaf and coil springs. Properties of a typical steel in this group are as follows: Yield point, 186,400 psi; tensile strength, 199,400 psi; elongation in 2 in., 12 percent; reduction in area, 39 percent; Brinell hardness, 386.
C–V	C 0.65–0.75 Mn 0.65–0.85 Si 0.30–0.40 V 0.05–0.10	Usually—OQ+T	
Cr–W–V	C 0.40–0.65 Mn 0.20–0.35 Si 0.20–0.35 Cr 1.00–2.00 W 1.50–2.50 V 0.20–0.40	Usually—OQ+T	These steels are intended for service at temperatures higher than about 750 F, depending upon the maximum stress and the permissible loss in working strength. They are used for applications too severe for chromium-vanadium spring steels because they possess higher creep strength.
Si–Mo–V	C 0.55–0.65 Mn 0.80–1.00 Si 1.80–2.10 Mo 0.45–0.60 V 0.30–0.40	Usually—OQ+T	
Mn–Si–Mo–V	C 0.50–0.60 Mn 1.00–1.25 Si 1.80–2.10 Mo 1.20–1.40 V 0.30–0.40	Usually—OQ+T	
Cr–Mo–V	C 0.35–0.40 Mn 0.40–0.60 Si 0.20–0.35 Cr 2.25–2.75 Mo 0.40–0.60 V 0.22–0.30	Usually—OQ+T	

[1] Symbols given under the column on heat treatment have the following meanings: OQ—Oil Quench; T—Temper.

Table V—Vanadium-Containing Cast Steels

Vanadium Cast Steels				Typical Tensile Properties of a Steel in this Range[1]					
Type	Composition, percent	Type of Heat Treatment[2]	Representative Applications	Heat Treatment[2]	Yield Point, psi	Tensile Strength, psi	El. in 2 in., percent	Red. in Area, percent	Izod Impact, ft lb
C–V	C 0.28–0.42 Mn 0.75–1.00 Si 0.25–0.50 V 0.15 min.	Usually—N+T Sometimes—DN+T Occasionally—Q+T	Locomotive wheel centers, driving boxes; ladle trunnions; large gears; valve bodies; cylinders.	N+T	60,200	93,800	24	47	33
Mn–V	C 0.26–0.38 Mn 1.20–1.80 Si 0.25–0.50 V 0.08–0.12	Usually—N+T Often—DN+T Sometimes—DN Occasionally—Q+T	Locomotive crossheads, cylinder heads, truck frames; forging hammer rams, bearing caps, crankshafts; hammers and dies for crushing machinery.	N+T	68,000	98,900	27	60	53
Ni–V	C 0.25–0.35 Mn 0.85–1.10 Si 0.25–0.50 Ni 1.25–1.75 V 0.08 min.	Usually—DN+T Often—N+T Sometimes—DN Occasionally—DA or N+Q+T	Couplers; eccentric cranks; rolls; gears; pinions.	N+T	68,000	96,000	28	55	58
Mo–V	C 0.35–0.50 Mn 0.50–1.00 Si 0.25–0.50 Mo 0.25–0.40 V 0.05–0.15	Usually—N+A+Q+T Sometimes—N+Q+T Occasionally—N+T	Centrifugally cast gun tubes.	N+A+Q+T	73,000	99,000	26	58	40
Mn–Mo–V	C 0.25–0.35 Mn 1.20–1.50 Si 0.25–0.50 Mo 0.30–0.60 V 0.10–0.20	Usually—N+Q+T Sometimes—DN+T	Breech-block castings for guns.	N+Q+T	156,700	168,500	16	38	—
Cr–V	C 0.15–0.45 Mn 0.50–1.50 Si 0.25–0.50 Cr 0.50–1.25 V 0.10–0.25	Often—N+Q+T or DN+T Occasionally—N+T or T only	Crusher jaws and plates; dipper fronts and bodies; power shovel castings.	DN+T	64,900	94,300	28	57	60
Cu–V	C 0.15–0.45 Mn 0.50–1.50 Si 0.25–0.50 Cr 0.50–1.15 V 0.08–0.15	Often—N+T or DN+T (T within precipitation hardening range)	Couplers; gear housings; brake-heads; pump frames; valve bodies.	DN+T	88,150[3]	106,150	24	51	42
Cr–Mo–V[4]	C 0.20–0.35 Mn 0.50–0.90 Si 0.25–0.50 Cr 0.80–1.10 Mo 0.15–0.35 V 0.05–0.15	Usually—N+Q+T Occasionally—DN+T	Castings for wear resistance requiring a thin case, such as cams and gears.	N+Q+T DN+T	101,500 62,800	128,000 88,800	— 31	56 62	— 52
Cr–Mo–V[3]	C 0.15–0.40 Mn 0.50–0.90 Si 0.25–0.50 Cr 2.25–2.75 Mo 0.20–0.50 V 0.22–0.30	Usually—N+Q+T Occasionally—DN+T	High strength castings resistant to service wear. Rolls for pulverizing machinery.	N+Q+high T N+Q+low T	119,650 138,350	131,900 152,850	17 15	65 46	63 40

[1] The tensile properties represent typical steels within the composition range shown, but are not meant to be either average or minimum values.
[2] Symbols given under the columns on heat treatment have the following meanings: N—Normalize; DN—Double Normalize; T—Temper; Q—Quench; A—Anneal.
[3] Suitable for nitriding.
[4] Composition of this steel as follows: 0.16C, 1.43Mn, 1.15Cr, 0.11V.

formity of the steel after it has been heat-treated.

However, the principal advantages of vanadium in castings are realized when the steel is in the heat-treated condition. As in the case of forged and rolled steels, vanadium in amounts above 0.08 percent is particularly beneficial in raising the yield strength, the ductility and the impact strength of steel castings that have been normalized. Ductility values of these steels are quite high for a rather broad range of heat treating temperatures, and the grain size of any vanadium-containing steel is smaller than that of an equivalent steel without vanadium.

When cast steels are quenched and tempered to obtain greater strengths, vanadium improves the uniformity of hardness throughout the casting. The ductility of the steel in proportion to the strength, is raised. To secure a given hardness, the tempering temperature can often be higher, thus putting casting in a more stress free condition. Warpage and distortion are reduced, and the tendency of castings having sudden changes in section size to crack is minimized.

Manganese-vanadium and nickel-vanadium steels are used for castings that are to be normalized and tempered to give a yield strength of approximately 60,000 psi, a tensile strength of 90,000 psi, an elongation of 25 per cent, and a reduction in area of about 50 per cent. Manganese-molybdenum-vanadium steel were used during the war in ordnance castings that had yield strengths over 150,000 psi, which is high for cast steel. Manganese - molybdenum - vanadium cast steels of lower molybdenum content are suitable when more moderate tensile strength and superior ductility and impact strength is needed. Copper-vanadium steels have a low carbon content, but high strength is obtained by precipitation hardening; thus, they are less sensitive to thermal abuse during welding, and to cracking in the molds.

The chromium-molybdenum-vanadium steels shown in Table V are about the only cast steels, other than the one per cent aluminum steels, that can be nitrited to a high surface hardness. The inherent tendency of aluminum-containing steels to produce cold shuts and so-called "alligator skin" has rendered its use difficult in castings, especially in thin sections. Of the two types of steels that are listed, the lower chromium type is for applications in which a nitrided case of slightly greater hardness and wear resistance is required than that obtainable with carburized steel. Steels of this analysis have been used extensively for high strength centrifugal castings, and are also applicable in cases where resistance to hydrogen penetration is important. The high chromium type is intended for applications requiring full hardness and wear resistance in the nitrided case, which has a toughness not usually possessed by aluminum-containing steels.

Nodular Cast Irons

From "Nodular Cast Irons, Their Production and Properties", by H. Morrogh and J. Grant, *Metallurgia*, July 1948.

UNTIL RECENTLY the only method of obtaining the graphite in a cast iron in a nodular form was by a lengthy annealing process. As a result of much research work on the fundamental aspects of graphite formation, the British Cast Iron Research Association has developed a process whereby graphite produced on solidification is in the nodular form. The resulting iron, although not as good as malleable iron, is a distinct improvement on normal flake graphite irons, and the process can be hailed as an outstanding development in cast iron metallurgy.

The process involves the solution of an appropriate amount of cerium in molten cast iron of appropriate composition shortly before casting. The principal composition requirements for the iron to be treated with cerium are:

1. The iron must solidify grey even without the cerium addition.
2. The iron must be of hyper-eutectic carbon content. When the nickel content of an iron exceeds 10 percent it need not be hyper-eutectic.
3. The silicon content can have any value, but is preferably within the range 2.3 to 7 percent.
4. The sulphur content of the metal to be treated should be as low as possible and after treatment it should not exceed 0.02 percent.
5. The phosphorous content must not exceed 0.6 percent and should preferably be below 0.1 percent.
6. Manganese, copper, nickel, chromium and molybdenum can be present in any amounts singly or in any combination, provided condition No. 1 is observed.

The most important of these requirements are those covering the carbon and sulphur contents.

The improvement in mechanical

Table I—Influence of Cerium on Remelted Hematite Pig Iron

Dia. of test bars, in.	Transverse rupture stress, tons/sq in.		Deflection, in.		Tensile strength tons/sq in.		Brinell hardness number		Impact strength, ft-lb	
	Without Ce	With Ce	Without Ce	With Ce	Without Ce	With Ce	Without Ce	With Ce	Without Ce	With Ce
1.6	23.0	44.2	0.20	0.32	11.2	24.2	154	186	....	....
1.2	28.8	45.3	0.28	0.38	14.3	24.6	160	198	....	....
0.875	30.7	47.1	0.18	0.23	16.6	26.6	162	199	12	43
0.6	30.8	57.4	0.11	0.22	18.6	29.5	198	239	....	....

Table II—Influence of Double Treatment (Ce + inoculant)

No.	Percent of Principal Elements						Transverse rup. stress, tons sq in.	Deflection, in.	Tensile strength, tons/ sq in.	B.H.N.	Impact, ft-lb
	T.C.	Si	Mn	S	P	Ce					
1	3.67	2.67	0.86	0.005	0.051	0.040	56.9	0.60	26.0	221	54
2	3.49	2.89	0.88	0.008	0.055	0.058	62.0	0.60	33.4	238	84

Table III—Composition and Structure of Melt Numbers

Melt No.	Treatment and Additions	Chemical Composition, percent							Structure
		T.C.	Si	Mn	S	P	Ce	Cu	
V.835	Single. 70 gm mischmetall to 65 lb tap.	3.74	2.65	0.53	0.006	0.024	0.053	—	Quasi-flake graphite and a few hypereutetic graphite nodules in a matrix of ferrite and pearlite. V.835 was white in the 0.875 in. and 0.6 in bars. V.980 was white in 0.6 in. bar.
V.980	Single. 35 gm mischmetall to 70 lb tap.	3.76	2.48	0.85	0.012	0.051	0.029	—	
V.895	Double. 70 gm mischmetall to 65 lb tap. 6½ oz S.M.Z.	3.55	3.01	0.89	0.004	0.044	0.053	—	Well developed nodular structure in a matrix of ferrite and pearlite.
W.3	Double. 90 gm mischmetall to 70 lb tap. 10 oz S.M.Z.	3.60	2.33	0.84	0.011	0.044	0.045	2.19	Nodular structure with some quasi-flake graphite in the 1.6 in. and 1.2 in. bars of W.3. The matrix was almost entirely pearlitic, the ferrite decreasing with decreasing section.
W.30	Double. 110 gm mischmetall to 70 lb tap. 10 oz S.M.Z.	3.68	2.34	0.77	0.009	0.035	0.054	1.49	
W.172	Inoculated.	3.04	1.92	0.84	0.032	0.041	—	—	Pearlitic iron with medium sized flake graphite.
Nod. 67	Single. 42 gm mischmetall to 60 lb tap.	3.85	2.69	0.49	0.012	0.028	0.029	—	Quasi-flake graphite.
W.7	Double. 65 gm mischmetall to 80 lb tap. 9 oz S.M.Z.	3.56	2.82	0.81	0.012	0.035	0.034	—	Nodular graphite.
V.636	8 oz. Fe Si (80%) to 80 lb tap.	2.91	2.16	0.64	0.025	0.028	Ni 1.92	Mo 1.18	Flake graphite. Acicular.

Mischmetall is an addition containing 50 percent cerium.

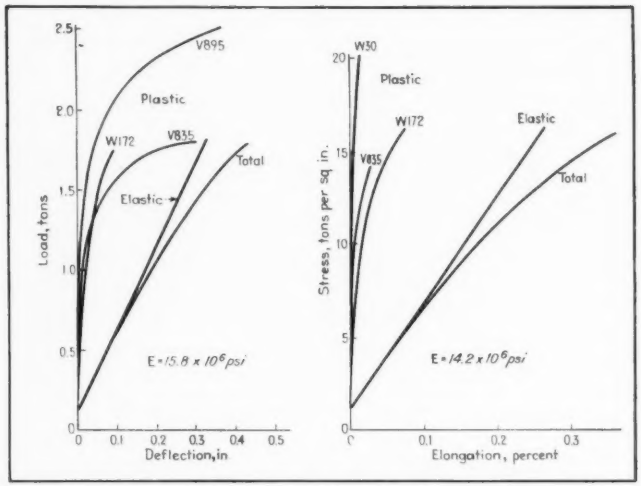


Fig. 1 (Left)—Transverse set and deflection curves for flake-graphite iron, 1.2 in. bar.
Fig. 2 (Right)—Tensile set and extension curves for flake-graphite, W.172 1.2 in. bar.

properties resulting from the cerium treatment is indicated in Table I in which the mechanical properties obtained on two sets of test bars are tabulated. The bars were cast from two melts of the same iron to one of which the appropriate amount of cerium was added. The only significant differences in analysis were the reduction of sulphur from 0.023 to 0.007 percent due to the cerium treatment and, of course, the presence of 0.040 percent cerium. The mechanical properties of the bars cast from the treated material are at a very much higher level and immediately fall into the range of properties covered by heavy-duty cast irons.

Irons produced by the simple addition of cerium to the molten metal before casting, will usually have a microstructure consisting of a mixture of hypereutectic nodules, together with quasi-flake graphite. This process is referred to as the "single treatment" process to distinguish it from a further elaboration of the process by which entirely nodular structures can be produced. This modification has been achieved by the introduction of what is known as the "double treatment" process, which involves the addition of a graphitizing inoculant to the molten metal simultaneously with, or immediately after, the cerium addition. By this double treatment process it is possible to obtain entirely nodular structures with the development of a new high level of mechanical properties.

Table II gives the analysis and mechanical properties of the two nodular

Table IV—Mechanical Test Results on Five Types of Nodular Cast Iron

Melt No.	Diameter as-cast, in.	Transverse as-cast: Trans. rup. stress, tons/sq in.	Transverse as-cast: Deflection, in.	Transverse as-cast: Mod. of elasticity psi × 10^6	Transverse machined: Trans. rup. stress, tons/sq in.	Transverse machined: Deflection, in.	Transverse machined: Mod. of elasticity psi × 10^6	Tensile: Ult. tensile stress, tons/sq in.	Tensile: Mod. of elasticity psi × 10^6	Ratio Trans./Tens.	B.H.N.	Impact, 0.798 in. dia, ft-lb	Compression: Ult. compression stress, tons/sq in.	Compression: Mod. of elasticity, psi × 10^6
V.835	1.6	40.7	0.34	18.2	45.0	0.43	18.9	23.0	19.4	1.8	178	48 51	54.4	
	1.2	48.6	0.54	20.5	47.1	0.57	20.0	25.6	20.8	1.9	187	32 51	76.0	20.8
	0.875	All 0.875 in. and 0.6 in. diameter bars were white												
	0.6													
V.980	1.6	48.5	0.47	19.4	47.2	0.59	19.0	22.4	20.2	2.2	178	51 33	54.8	
	1.2	48.1	0.48	20.8	51.4	0.88	20.8	24.0	20.2	2.0	184	75 110	62.0	21.3
	0.0875	64.2	0.38	22.2	55.7	0.51	21.8	25.4	19.1	2.5	204		56.4	
	0.6	All 0.6 in. diameter bars were white												
V.895	1.6	61.6	0.52	22.0	63.2	0.63	21.6	28.8	23.8	2.1	213	78 62	71.6	
	1.2	70.2	1.03	23.4	69.6	0.95	23.4	30.6	24.1	2.3	230	55 59	66.0	23.6
	0.875	73.4	0.44	24.9	63.2	0.29	25.0	35.2	24.0	2.1	249	109 >120	72.4	
	0.6	77.6	0.36	21.9	80.2	0.36	22.8	34.8	21.4	2.2	272		70.0	
W.3	1.6	65.4	0.33	22.1	69.4	0.45	21.4	37.2	22.8	1.8	258	78 55	74.8	
	1.2	72.9	0.50	23.3	77.8	0.70	22.4	38.0	22.1	1.9	272	100 100	75.2	23.5
	0.875	73.8	0.26	24.0	79.2	0.32	22.1	38.2	22.8	1.9	290	106 >120	67.2	
	0.6	77.0	0.18	24.7	80.8	0.23	23.3	38.6	23.4	2.0	313		93.6	
W.30	1.6	68.4	0.42	22.1	73.8	0.58	22.1	34.2	24.2	2.0	262	110	——	
	1.2	71.9	0.54	22.8	64.0	0.42	23.1	37.8	23.4	1.9	271	55 73	66.4	23.8
	0.875	82.7	0.37	26.0	73.2	0.28	23.1	38.0	24.4	2.2	290	56 72	78.2	
	0.6	93.6	0.37	24.3	90.0	0.28	23.9	36.6*	23.4	2.6	307		84.0	
†W.172	1.2	44.9	0.43	15.8	——	——	——	21.7	14.2	——	——	—— ——	——	——

† Flake graphite iron. * Fracture showed inverse chill.

cast irons cast in the form of 1.2 in. bars—No. 1 produced by the single treatment process and No. 2 by the double treatment process. In both, the melt was treated with 0.14 percent cerium, but in the case of the double-treated iron 0.2 percent silicon was added as 80 percent ferro-silicon before casting.

Nodular cast irons can be regarded as new materials having mechanical and physical properties differing in many ways from those of heavy-duty grey cast irons and malleable cast irons. In spite of the nodular graphite structure, nodular irons are still relatively brittle and non-ductile materials. While they have a shock-resistance inferior to that of the best grades of malleable iron, they are much less brittle than grey irons containing the usual flake graphite structures. The development and application of a new material of this type entails the determination of a wide range of mechanical properties other than those usually reported, such as transverse rupture stress, tensile strength, and hardness. The designer is interested, for instance, in the fatigue, damping and elastic properties of the material and, although the metallurgical aspects of the process have been dealt with in some detail already in the literature, no attempt has yet been made to present a detailed survey of the special mechanical properties.

Table III lists melts used for the majority of the tests, melt W172 being included for comparison as representing the heavy-duty flake graphite irons. The last three irons listed were used in the investigation of the fatigue properties of nodular irons.

In Table IV the results of standard tests carried out on five nodular irons and the heavy-duty flake graphite iron are listed.

Plastic Laminates in Aircraft

From "Use of Plastic Laminates in Air Force Aircraft—Part II", by R. T. Schwartz, W. G. Ramke and J. K. Lang, Air Materiel Command, Wright-Patterson Air Force Base, presented at the Low Pressure Seminar of the Society of the Plastics Industry, June 29-30, 1948, Washington, D. C.

AMONG THE PROBLEMS encountered in the use of low pressure glass fabric base plastic laminates in aircraft are those of wet strength, exposure to weathering, and rain erosion.

Air Force experience in tropical regions, particularly in the Pacific area, has shown that one condition aircraft plastic parts must meet is that of satisfactory operation after being exposed to high humidity long enough to reach equilibrium as to dimensions, weight, and strength changes. The strength properties under these conditions are termed "wet strength" properties. For plastic materials whose wet strengths are lower than the normal properties, these lower values must be used for design purposes. It has been found convenient and practical for those laminates of aircraft interest to substitute immersion in water at room temperature (77 F) for exposure to high humidity at a somewhat higher temperature, for routine laboratory tests of wet strength. The time required to reach essentially constant strength on immersion may be as much as 30 days for ¼ in. thick laminates. However, thicknesses of faces used in aircraft sandwich construction are as low as 0.015 to 0.035 in. and the time required to reach equilibrium may be considerably less than thirty days.

Some finishes for glass fabric have been developed which greatly improve the wet strength of glass fabric base laminates. They consist of first heat cleaning the glass at high temperatures to remove all organic matter and then treating the fabric with a water repellant size. Owens Corning finishes 13, 14, and finishes of this type are commercially available. When glass fabric having either of these water repellant finishes is laminated with polyester resins the flexural wet strength after 24 hours water immersion is only about 10 percent less than the dry strength, and the flexural modulus of elasticity is not significantly lower wet than dry. The effect of the water repellant finish on the flexural wet strength does not seem to be permanent, because after 30 days water immersion, the strength of laminates made with Finish 13 or 14 glass fabric has dropped almost as much as that of heat treated glass fabric laminates, about 30 or 40 percent. Even after 30 days, however, the flexural modulus of elasticity of the Finish 13 or 14 laminate will not have dropped more than about 10 percent, whereas the heat treated laminate will have dropped about 30 percent.

Glass laminates have stood up much better than cotton and paper laminates under severe conditions of outdoor exposure, as far as dimensional and weight changes are concerned. Considerable periods of exposure to weather may weaken glass fabric base polyesters about 20 percent in ultimate flexural strength at the most as far as is known, but they do not induce warpage, delamination, crazing, softening, or cracking. Often the strength is increased after exposure, indicating that the curing periods normally regarded as sufficient may not develop the maximum strength of the material. Also service experience in tropical and arctic as well as temperate climates has not been known to deteriorate glass fabric base polyesters. No unsatisfactory reports have been received as to fungus attack in service.

A third major problem is that of rain erosion. The problem of rain erosion was first encountered in the Pacific, where planes were often forced to fly through heavy rain, and also rain and hail combined, and damage to glass fabric laminates was so severe that, sometimes the parts were worthless after a single mission. More recent service experience has shown that nose radomes made of glass fabric base polyesters were severely damaged by the combination of rain and hail during flight. Rain alone erodes through the plies of a laminate making it appear to have been sanded. Flight through rain and hail produces even more severe damage possibly because the hail damage provides focal points for erosion to start.

Wind tunnel tests confirmed the fact that erosion could be due to rain alone without the presence of hail or sand or any abrasive substance. Various laboratory tests have since been set up to simulate the effect of plastics traveling through rain at high speed. Most of these consist of a rotating arm or propeller at the ends of which plastic samples can be attached and rotated through a water spray at high velocity.

These tests supplied the following results: Heavier rainfall has been found to cause more rapid rates of deterioration than light rainfall. For instance, rainfall at three in. per hr and 2.5 mm median droplet size eroded glass fabric base polyesters and clear polymethyl methacrylate three times as fast as did rainfall at one in. per hr and 1.9 mm median droplet size. Higher speeds of the test piece have

also been found to increase the rate of rain erosion, the erosion time decreasing with about the sixth or eighth power of the speed. The use of test pieces of various shapes has shown that rain erosion is most severe on sharply curved leading edges. Test pieces of polyester glass laminates with a leading edge radius of curvature of $\frac{1}{4}$ in. eroded eight times as fast as did flat leading surfaces. Water temperature within the range of 40 to 80 F did not have much effect on the rate of rain erosion.

For an approximate quantitative estimate of resistance to erosion, based on time to initiate first perceptible erosion under comparable test conditions, the following are based on an arbitrary scale of assigning the rating of 20 to a good void-free polyester glass fabric base laminate.

Polymethyl methacrylate	100*
Polyethylene	100*
High pressure cotton fabric base phenolic, Grade C	20*
Low pressure bag molded cotton fabric base phenolic	15
High pressure melamine glass fabric laminate	2
Good void free glass fabric polyester laminate	20
Conventional vacuum bag molded glass fabric polyester laminate	1
Glass fabric polyester laminate molded under positive pressure, between male and female molds	4

*Not tested long enough to determine exact value.

The Air Force has several specifications in preparation to cover the quality control of laminating resins, glass laminated fabric base parts, and sandwich constructions. Qualification tests to be performed for the initial evaluation of the resin will consist mainly of the preparation of a laminate with a specified glass fabric and then tests of the laminate to see that it meets mechanical, physical, and chemical resistance requirements. The ultimate flexural strength requirement for this laminate, $\frac{1}{8}$ in. thick and made with 181-14 or 181-13 glass fabric, will be 45,000 psi minimum and the flexural modulus of elasticity requirement will be 2.5 x 10^6 psi minimum. Most of the rigid type polyester laminating resins should meet these requirements. There will in addition be wet strength requirements for the laminate—that its ultimate flexural strength must be above 25,000 psi after 30 days water immersion and flexural modulus of elasticity above 2.3 x 10^6 psi.

Engineering of Nuclear Power

From "The Outlook for Nuclear Power" by Cecil B. Ellis, *Journal of the American Society of Naval Engineers, Inc.*, February, 1949.

NUCLEAR POWER, it has been generally agreed, could be used to generate electrical energy and to propel large vehicles. But it is now three years since the end of World War II; and, so far as is known, no light bulb has yet been lit or engine turned by fission power. Many of the difficulties inhibiting the advance of these applications lie in the engineering field.

The construction of atomic piles illustrates some of these problems which must be solved by the engineer if atomic energy is ever to be satisfactorily harnessed. In one simple type of pile, air-tight aluminum cans, containing uranium metal, are imbedded at intervals throughout a large mass of pure graphite. Cooling water is passed through channels around the uranium-filled cans. The entire assembly is surrounded by a concrete shield several feet thick to prevent the escape of damaging radiation.

This enormously massive protective shield is the entity which dominates all practical power aspects. The radioactivity and neutron density within a pile producing heat at only 1 kw is so large as to require shielding equivalent to two feet of concrete. At the 100 kw level, competent authorities have estimated that the minimum weight of a nuclear powered automobile, according to present pile design possibilities, would be 50 tons.

Small piles are too heavy and too expensive to have many practical power uses, although they will always be valuable as neutron sources for research. The most important power piles will probably be built for the range from a few thousand kilowatts upwards. Practical power piles should also be designed to run at very high temperatures to increase efficiency.

To build a 75,000 kw nuclear plant would require a capital outlay of twenty-five million dollars. Such economic factors alone will probably force pile sizes into the range above 10,000 kw. As shown in Table I, the principle uses for atomic power lie in the field of heavy propulsion. But the only apparent means of greatly reducing the weight for a given power output is to find a way to decrease the size of the pile. The perimeter of the shield will then be smaller. If this reduced size can be achieved, however, there will necessarily be more BTU per second generated in each cubic foot of the pile, and the pile will run at a much higher temperature unless the efficieny of the coolant can be correspondingly increased.

One of the central engineering problems of the practical power pile, therefore, is to achieve rapid heat transfer from the uranium at high temperature to the coolant fluid. Most of the suggested power pile designs which have been published contemplate that the circulating fluid will issue from the pile at something like 1200 F. Coolants suggested have ranged from high-pressure helium gas to liquid metals such as sodium or lead. These working

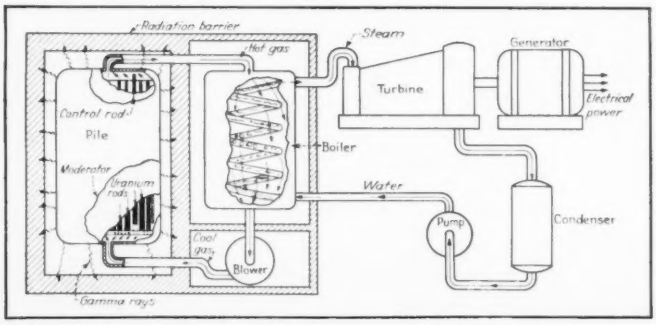


Fig. 1—Schematic diagram of a possible type of nuclear power plant.

Table I—Estimated Power Levels

Use	Estimated Power Level	Estimated Weight Replaceable by a Pile
Automobile	100 Kw	
Submarine	5,000 Kw	630 tons
Locomotive	6,000 Kw	250 tons
Large airplane	9,000 Kw	95 tons
Electric power for a small city	100,000 Kw	
Large battleship or carrier	150,000 Kw	12,000 tons
City of a million population	1,000,000 Kw	

fluids would then be led, probably, through an intermediate heat exchanger to a suitable engine for converting their heat to useful work. The closed-cycle gas turbine has been suggested by some designers. This engine would drive a generator which would produce electric power as the final output of the nuclear plant. Such a system is shown schematically in Fig. 1.

A number of problems must be solved before the above system can be constructed. A few of these result from the shift to high temperatures, but most of them have been partially solved in building the present piles.

(1) One of the first requirements is that neither the moderator, the coolant, nor any other material within the pile, such as the cans for the uranium or the coolant pipes, can contain any elements which are strong neutron-capturers. Otherwise, the chain reaction will be choked off. Table II lists the relative ability of various elements to absorb neutrons. Many of the common structural materials, such as steel, are immediately ruled out on this score. The requirements with respect to some elements are so extreme as to necessitate setting up new industries for producing materials of the necessary purity. Thus, less than one part of boron in a million can be allowed in a pile.

(2) From this restricted list materials, which are not subject to high temperature creep or weakening, must be selected for all the close tolerance locations.

(3) Materials exposed to the coolant must not react with it or corrode at high temperatures.

(4) Film formation of any kind on inner surfaces would decrease the vital heat transfer rates.

(5) The coolant or impurities therein, may be made radioactive while passing through the pile. This will make the pumping machinery radioactive, and, in case of trouble, impossible to repair except by remote control. For this reason, the pumps and the external lines of the coolant will probably require some radiation shielding also. To decrease the amount of shielded space and to protect the large power turbines from radiaactivity, the latter should probably be operated by a secondary thermal fluid, such as high pressure steam or mercury. This fluid may receive its heat from the primary coolant through a heat exchanger impervious to radioactivity.

(6) The intense neutron flux in the pile almost precludes the use of any organic materials since the neutron bombardment will disrupt the bonds of organic molecules. Similarly, radioactivity in the coolant will break down lubricating greases in the pumps. Many inorganic liquids would also be dissociated if used as coolants.

(7) In the same fashion, the strength and other physical properties of many structural materials are altered under intense neutron bombardment. This problem did not prove insurmountable in previous piles, but it may be especially bad when the materials are exposed to high temperatures.

(8) The cans holding the uranium must remain absolutely gastight at the elevated temperature since many of the heavy fission fragments form highly radioactive gases which must not be allowed to get out into the coolant lines.

(9) Some of these heavy fission fragments, from which the pile gets its heat energy, are themselves strong neutron-capturers. If their concentration is allowed to grow too high, they will "poison the pile" by choking off the chain reaction. Therefore, provision must be made for periodically replacing the partly used uranium cans by fresh ones. All this must be accomplished by remote control since everything is "hot," both thermally and radiologically.

Table II—Relative Neutron Absorbing Powers for Various Elements

Element	Relative Absorbing Power
Aluminum	0.4
Argon	1.0
Beryllium	0.01
Boron	710
Cadmium	2950
Carbon	0.0048
Chromium	2.5
Copper	4.3
Deuterium	0.03
Fluorine	0.01
Helium	0.00
Hydrogen	0.33
Iron	2.1
Lithium	66.0
Magnesium	0.31
Mercury	400
Nickel	6
Nitrogen	1.2
Oxygen	0.00022
Silicon	0.24
Silver	58
Sodium	0.4
Vanadium	5.

Such points as the usefulness of cadmium and boron as control rods, and the unsuitability of mercury as a coolant are evident from this table. These values are based on prewar measurements.

Enough has been said by now to show that the problems, though very difficult, are not fundamentally insoluble. A number of the engineering questions should benefit from research now being carried on by materials contractors and metallurgical and chemical contractors of the Office of Naval Research. Everyone believes that good power piles will be built sooner or later. For the stationary power plants, the scale of development will doubtless depend chiefly on economic factors.

Stress Corrosion of Alloy Steels

From "Stress-Corrosion Cracking in Alloy-Steel Gas Cylinders" by R. G. Gifkins and W. P. Rees, *Metal Treatment and Drop Forging* (London), Autumn 1948.

THREE FACTORS known to be important in causing stress-corrosion cracking in steels are: (1) Stress; (2) corrosive conditions; and (3) time. Factors relating to the steel which may be of importance are: (1) Chemical composition; (2) heat treatment; (3) condition of the surface. The experiments reported deal largely with effect of stress under constant corrosive conditions and with the effect of changes in the corrosive environment.

Experiments on conditions causing stress-corrosion cracking entail the use of a large number of specimens and apparatus by means of which several specimens can be tested simultaneously; simple test specimens and methods of stressing are therefore desirable. The specimens used were

Table I—Effect of Stress on Time for Failure
(Tests made using machined surface specimens, with a wick and hydrogen sulphide in saturated air.)

Test No.	Stress, tons per sq in.	Duration of Test	Examination by Crack Detector	Remarks & Results of Microscopic Examination
QJJ 1C	55	16 hr	Cracks	Wide cracks with hook-like branches
" 2C	55	"	"	
" 3C	50	22 "	"	
" 4C	50	"	"	
" 3D	45	16 "	"	
" 4D	45	40 "	"	Stubby fissures often leading to wide cracks with hook-like branches
" 1E	40	16 "	"	
" 2E	40	20 "	"	
" 5C	35	19½ "	"	
" 3E	35	40 "	"	Small fissures—cracks with hooked branches, finer than QJJ 4D
" 1F	30	5 days	"	Small fissures leading to fine branching cracks
" 2F	30	7 "	Many fine cracks	
" 3F	25	4¼ "	Cracks	
" 4F	25	7 "	"	Cracked specimen broken by bending in vice; some cracks had penetrated half the thickness of testpiece

All specimens except QJJ 1F, QJJ 2F & QJJ 4F broke; these were removed for examination.

Tests made with the wick, using hydrogen sulphide in saturated air.

QJJ 10A	20	4 days	Possible cracks	Small fissures
" 11A	20	7 "	Cracks	Deep, fairly wide fissures
" 1G	15	7 "	"	
" 2G	15	14 "	Possible cracks	Small narrow-mouthed pits and fine cracks
" 10B	10	7 "	" "	Small narrow-mouthed pits
" 11B	10	14 "	Many cracks; deep corrosion	Wide-mouthed cracks about 0.02 in. deep
" 9C	7½	7 "	Doubtful cracks	
" 10C	7½	21 "	Doubtful cracks	Corrosion pits but no cracks
" 16A	5	15 "	Possible cracks	Corrosion and one wide deep fissure
" 17A	5	31 "	Doubtful cracks	No cracks. Considerable corrosion

None of the specimens failed in the tests.

Table II—Preliminary Experiments

Test No.	Stress, tons per sq in.	Corrosive Conditions		Duration of Test	Examina- by Crack Detector	Remarks and Results of Microscopic Examination
		Agent	Humidity			
PRH1A (1)	50	Solution of H_2S in water	Saturated	10 weeks	No cracks	Machined surface on specimen
PRH1A (2)	60 (approx.)	H_2S in air	Unsaturated	2½ days	Many cracks	Specimen first subjected to conditions of test PRH1A (1)
PRH6A	50	H_2S in air	Unsaturated	6 weeks	No cracks	Heat-treatment scale on surface
PRH5A (1)	50	Solution of H_2S in water	Saturated	18 days	No cracks	Heat treatment scale on surface
(2)	60 (approx.)	H_2S in air	Unsaturated	9 days	No cracks	Same specimen as PRH5A (1)
(3)	60 (approx.)	H_2S in air	Saturated	7 days	Many cracks	Same specimen as PRH5A (1)
PRH8A (1)	58 (approx.)	H_2S in air	Unsaturated	28 days	No cracks	Heat treatment scale on surface
(2)	60 (approx.)	H_2S in air	Saturated	4 days	Cracks present	Same specimen as PRH8A (1)
PRH3A	60 (approx.)	H_2S in air	Saturated	4 days	Many cracks	Heat Treatment scale on surface

All the tests, except PRH1A (2) and PRH3A (where the specimens failed), ended by the specimens being taken out for examination. No wick was used except for PRH5A (3), PRH 8 A (2) and PRH3A.

strips 3½ by ½ by 1/10 in. machined from used cylinders. They were stressed in a jig designed to give a uniform bending moment. The jig, with the stressed specimen in position, was small enough to fit comfortably into a glass jar, fitted with a sealing lid, into which known gas mixture could be passed.

Experience with hydrogen cylinders showed that nickel-chromium, molybdenum steel was susceptible to stress-corrosion cracking and as there were available a number of hydrogen cylinders which had been cut up for periodical inspection, tests have been confined to steel from two of these cylinders in both of which cracks had developed in service. Most of the tests have been made on a steel (QJJ) of the following composition: C, 0.28; Si, 0.31; S, 0.038; P, 0.028; Mn, 0.66; Ni, 2.25; Cr, 0.75, and Mo, 0.65 percent. The hardness of this steel was 369 Vickers and of a similar steel (PRH) 316.

Ruthenium

From "Ruthenium," *Metallurgia*, Manchester, England, March 1949.

RUTHENIUM, a rare metal of the platinum group, has few commercial applications as yet but prominent among these are the uses of platinum-ruthenium alloys to replace the more valuable platinum-iridium alloys for pen points and electric contacts.

As far back as 1918, William R. Mott in his studies of the volatility of refractory materials in the carbon arc estimated the boiling point of ruthenium at 4,150 C, decidedly higher than the boiling points of platinum and aluminum oxide. (Volume 34 of the Transactions of the Electrochemical Society). In a later study he reported that ruthenium gives a bright blue arc core and a yellow arc shell when burned in a carbon arc.

Harold G. Bain prepared metallized glass oxygen-electrodes of the platinum metals including ruthenium, as reported also in the Transactions of the Electrochemical Society. The ruthenium solution used contained 1 percent ruthenium chloride in 4 normal hydrochloric acid. As in the cases of the other platinum metals, no ruthenium electrode gave reproducible and constant values for the oxygen potential.

Ruthenium like osmium forms a hexacyanide, and it has been suggested that ruthenium can be deposited from a cyanide bath. Ruthenium dissolves in fused potassium hydrate. Tetravalent ruthenium forms a sulphide, a selenide and a telluride. Three chlorides and five oxides are known.

TECHNICAL NEWS

Quartz Film Is Both Conductor And Insulator

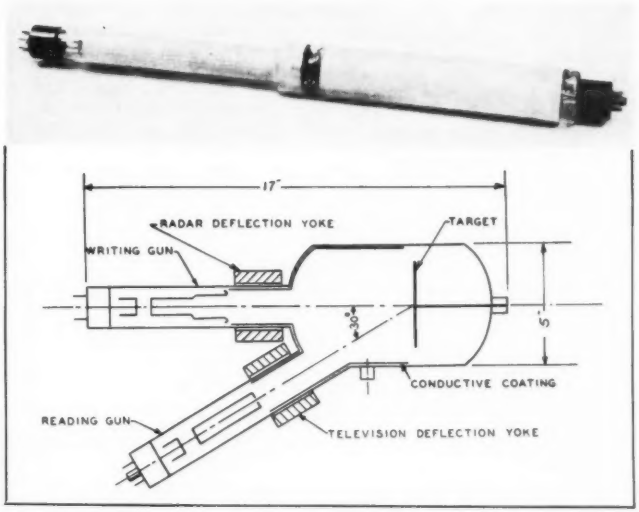
A THIN LAYER OF PURE QUARTZ that is both an electrical conductor and an insulator is being used in a special electron tube to retain and intensify the fleeting images on a radar screen. The tube, called the Graphechon is a "booster" device that is placed between the radar beam receiver and the television kinescope reproducer. Possessing "visual memory", the device retains for more than a minute images that otherwise would have a life of less than one-millionth of a second.

Because of this capacity, the tube will increase the efficiency and ease of monitoring search radar, will heighten the effectiveness of Teleran, the television-radar navigational aid, and will make possible the more exact observation and recording of oscilloscope traces.

The heart of the Graphechon is a metal target, 3 in. square, coated on one side with a layer of pure quartz 20-millionths of an inch thick. In the basic tube, two beams in the legs of a V-shaped envelope are aimed at this target. One is a radar beam, which "writes" on the quartz surface; the other is a iconoscope-type beam—as used in a television camera—which "reads" from the surface. Unlike a fluorescent screen, the target is not light sensitive, but is sensitive to electrical charges.

The beam of electrons from the "reading" gun strikes the target and knocks off secondary electrons, which fly to the conducting coating that lines the tube. Removal of negative electrons builds an increasing positive charge on the target surface, until a maximum point of equilibrium is reached. When this occurs, the excess of secondary electrons, over the beam current, returns to the target, maintaining the electrical equilibrium. The quartz coating acts as an insulator and permits charging of the surface to a voltage higher than that of the metal sheet.

At this point the iconoscope beam has prepared the target for "writing" by the radar beam. When the radar receiver picks up a reflection, the signal turns on the radar beam of electrons that crashes through the quartz layer, makes it conducting at that point, and there discharges the voltage.



"VISUAL MEMORY" TUBE has a quartz target that is sensitive to electrical charges. Upper view shows double-ended construction that is the present version of the original V-shaped configuration shown in the lower view.

The iconoscope scanning beam then knocks secondary electrons from that spot on the target in an effort to bring it back to equilibrium. This removal of electrons produces a signal on the target that is amplified and applied to the kinescope.

Scanning occurs 30 times a second and sometimes as many as 2,000 scans are required to bring the whole signal area of the target back to equilibrium; that is, to read off the signal completely. Thus the image can be retained for approximately a minute.

The radar antenna revolves once every five seconds and repeats each signal at that interval. By coordinating the reading speed of the iconoscope with the writing speed of the radar beam, all the signals can be seen on the kinescope with a high level of brightness.

If a "progressive" picture of a moving object is desired, the "reading" can be slowed to the maximum time interval and the radar beam will add eleven signals to the image before the original screen trace or pip is lost. The resulting teardrop-shaped pip indicates the object's direction—toward the rounded end—and will be curved to duplicate the change of course.

The first major application of the Graphechon is expected to be in Teleran, in which a composite television picture comprising radar pattern, its associated ground map and other information is transmitted from ground to plane. This all-electronic converting scheme, since it "memorizes" with very slow deterioration signals that otherwise fade rapidly, makes it possible to transmit a much stronger picture to the pilot-viewer.

Of equal importance is the fact that radar signals, in the form of electricity rather than light, can be amplified. The image that appears on the fluorescent surface of a radar scope is so dim that it cannot be telecast without the use of complicated optical booster systems. With the Graphechon, the radar pattern is kept in the form of an electrical charge, which may be readily amplified, until it reaches the kinescope.

Cathode ray oscillograph traces, which occur in intervals so short they are measured in millionths of seconds, can also be retained for scrutiny or reproduction.

Since the prototype was developed and built, the tube has been modified

to do away with the "V" formation of the guns, which poduced some distortion in the "reading." The modified model has the radar and iconoscope beams approaching the target from opposite ends of a regular cylindrical tube. Instead of a single quartz on a metal plate, quadruple-layer construction is used. Starting at the radar side of the assembly, this construction consists of a layer of fine copper screen with 500 wires to the inch, a film of collodion one-millionth of an inch thick, a layer of aluminum four-millionths of an inch thick and, finally, the layer of insulating-conducting material.

The Graphichon was developed by Louis Pensak, Research Physicist at the RCA Laboratories, Princeton, N. J.

Complete Hudson Engines Balanced Dynamically

A MACHINE that can balance the rotating and reciprocating parts of an engine—crankshaft, clutch, dampener, flywheel, connecting rods and pistons —while they are in motion is now in use at the Hudson Motor Car Company's plant in Detroit.

The $30,000 machine, which is 20 ft long and weighs ten tons, consists of a large electric motor, a "brain-box" amplifier and translator, a cradle on which the engine to be balanced rests, and a double hydraulic drilling unit operated by selsyn generators that are activated by the "brain-box."

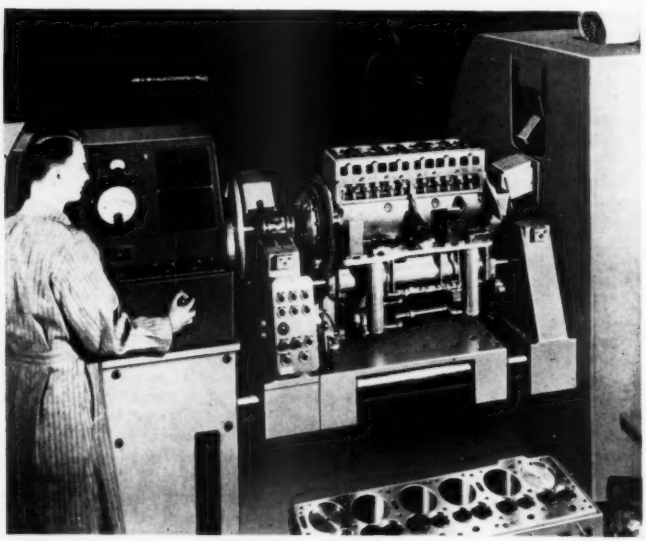
Engines are taken off the production line and mounted on the cradle. This fixture hangs on wires ⅛ in. in diameter and 18 in. long so that the engine and cradle are suspended.

Hydraulically operated "dogs" or clamps hold the engine in the cradle. The electric motor transmits power through a flexible coupling and rotates the crankshaft at 450 rpm. To compensate for variations in torque caused by changes in electric power flow or stiffness of the new engine, this speed is held constant by the "brain-box".

As the engine revolves, the minute vibrations that would tend to shake the engine during operation in a finished automobile develop enormously magnified vibrations in the supporting wires of the cradle.

The "brain-box" picks up these vibrations from two separate planes of vibration: the first from the rear half of the engine; the second, from the front half. The electronic circuits provide a measure of the unbalance causing the movement of the cradle and automatically locate the unbalance.

Selsyn motors, running in pairs, automatically synchronize their speeds, and electrical impulses are conveyed to the automatic drilling equipment. The "brain-box" signals the drills where to drill out the unbalance on both the flywheel on the rear end of the crankshaft and the dampener on the front end of the crankshaft. In addition, the "brain-box" signals the drills how deep to drill.



ENGINE BALANCER measures dynamic unbalance in rotating parts and automatically drills out flywheel and dampener to bring complete engine into balance.

Next Month's P.E. To Keynote "Cost Reduction"

DURING THE PAST FOUR MONTHS, the editors of PRODUCT ENGINEERING have traveled 18,000 miles and visited hundreds of industrial plants to find out how design engineers can and are meeting the demands of the buyer's market. More than 200 studies, including charts and tables for simple cost comparisons, will fill 88 pages of the June PRODUCT ENGINEERING.

Near-Vacuum Wind Tunnel Simulates Height of 80 Miles

NEAR-VACUUM FLIGHT CONDITIONS, encountered by rockets from 50 to 80 miles above the earth, are to be studied under man-made conditions in a new type of wind tunnel installed at the University of California at Berkeley.

The ordinary wind tunnels of the world, now countable by the dozens, yield scientific flight data from subsonic to supersonic under conditions at sea level, but give little information of value in determining conditions in the far above atmosphere regions reached by modern rockets. Even the data obtained from rocket-borne instruments sent high aloft are not reliable, because the effects of atmospheric conditions on instruments at such altitudes are not accurately known.

These high-up conditions are duplicated in the five-by-seven foot test chamber of the new tunnel by powerful steam jet vacuum pumps. When the vacuum approaches the conditions existing 80 miles above the earth, a molecule in motion in the chamber has a chance of bumping into another molecule every 10 ft. At sea level, a molecule in the free air would strike another every 0.0001 inch.

When the vacuum in the test chamber of this new tunnel has been created, air or gas is directed from a special accelerating nozzle into a 4-in. test section that contains the model under test. Nitrogen, helium or other gases can be used for special studies.

Washington Notes

Congress Favors Passage Of Science Foundation Bill

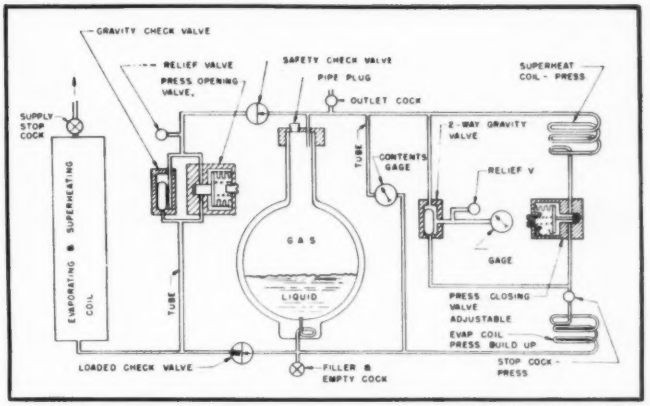
The government finally is going to set up a National Science Foundation. Congress is willing to take the kind of law that President Truman likes and, if present plans are not altered, Congress will vote a beginning $2-million to start the program.

Scientists, frustrated after three years of legislative and executive disagreement, are hopeful that the new election-borne weight now given the President's words will help bring the long-sought foundation into being. A total of $15,000,000 for fiscal 1950 for the foundation to start its program is listed in the budget.

A bi-partisan bill, identical with one which passed the Senate and died in the House of Representatives last year, has already been introduced in the Senate. Heading the list of senators who introduced the bill (S. 247) is the new chairman of the Labor and Public Welfare Committee where the bill has been assigned, Sen. Elbert D. Thomas, D. Utah. Other sponsors include two Democrats, Senators Harley M. Kilgore, W. Va., and J. William Fulbright, Ark., and three Republicans, H. Alexander Smith, N. J., Guy Cordon, Ore., and Leverett Saltonstall, Massachusetts.

The bill was originally sponsored in the Republican Eightieth Congress by Sen. Smith. It meets the objections the President raised in 1947 when he killed a foundation bill by pocket veto. Main objection at that time was appointment of the director of the foundation by a large group of members. Under the present bill, the President appoints both the director and the members, with advice and consent of the Senate.

The foundation's big jobs are planned to be the support of research, particularly fundamental research, with grants of federal funds and the awarding of scholarships and fellowships to scientists and prospective scientists. As called for in the bill, it would function through divisions covering different sciences. A minor point of dispute in the last Congress was whether special groups should be specified for attacks on major diseases, but this was compromised by providing that the foundation could set up such other divisions and commissions as it deemed possible. These decisions would be made by the director and 24-member board.



USAF Air Materiel Command Photo

Small Liquid-Oxygen Converter for Aircraft

An oxygen converter system using liquid oxygen instead of the gaseous medium is being devised by engineers of the Air Materiel Command's Aero Medical Laboratory and the Pioneer Division of Bendix Aviation Corp. The entire mobile oxygen-liquefication plant can be contained in one trailer-truck.

With a 228-lb saving in weight and a 450 percent reduction in space, the volume of oxygen available for human consumption is increased by 44 percent. These advantages are gained because, when changing from a liquid to a gas, the relative volumes are in a ratio of 1:800, which means that 1.0 cu ft of liquid oxygen will provide about 800 cu ft of gaseous oxygen upon vaporization.

The converter consists of a metal container for the liquid oxygen with a vaporizing coil and the necessary safety valves and specially designed operating valves. The liquid, upon vaporization, is forced through the oxygen system as a result of the pressure formed by the change from a liquid to a gas.

Insulation for the small units installed on planes was easily solved by applying the laboratory method of preserving the necessarily low temperature of —297 F—that of vacuum-walled containers. Recent Aero Medical Lab tests showed that the amount of liquid oxygen needed to produce breathing oxygen for a crew of a B-17 in an amount that would compare with the present gaseous system would be a little less than a cubic foot.

The mobile unit can produce 80 lb of liquid oxygen an hour, which, in the gaseous form, would be about 1000 cu ft. One gallon weighs about 9¼ lb in comparison to 7½ lb for an equal amount of water. Each trailer has its own power plant, air compressor, air purifier, refrigeration unit, and air-separator group.

USAF Doing Big Business With "Small Business"

Small business, classed as establishments using fewer than 500 employees, was awarded nearly half of the total number of contracts for purchases during the past six months, according to tabulations by Air Material Command Headquarters, Wright-Patterson Air Force Base, Dayton, Ohio.

Furthermore, key AMC officials estimated that sub-contracts let to small business would total many more millions of dollars. Bulk of this latter total was in components going into the production of military aircraft.

Maj. Gen. K. B. Wolfe, Director, Procurement and Industrial Planning, for AMC stated that there are thousands of small business firms throughout the country eligible to bid on commodities required in building up and maintaining a modern Air Force. Participation by small business in future bidding should increase greatly, thanks to an educational program recently initiated by Brig. Gen. H. A. Shepard, Chief, Procurement Division. Nor does it involve having a manufacturer's representative present at bid openings —an expensive procedure for the aver-

age small business establishment. The system is simple:

A small business firm needs only to write to the Commanding General, AMC, Wright-Patterson Air Force Base, Dayton, O., Attention:-MCPPXS72, Source & Price Records. The firm will be sent a regular form for registration of data on the type of its products and allied information.

The firm's name then is placed on the register for bidders. Each time, thereafter, when bids are to be published on an item the firm can produce, it will be sent a letter to determine if the firm is interested. If it is an IFB—Invitation for Bidders—with complete information concerning quantity, delivery dates and specifications will be sent on the published items. Ample time is allowed between publishing dates and bid opening dates for firm officials to determine its bid figures.

Air Force regulations and Public Law 413, govern the awarding of contracts. There are no exceptions or deviations from provisions set forth in both.

As a guide in preparing future bids, abstracts of bidding on each contract are made available to those submitting bids. These abstracts are on record at the Contractors Relations Office, Wright-Patterson Air Force Base; Office of the Director, Procurement & Industrial Planning, Washington, D. C., and the seven Field Offices.

Plastics Advisory Committee To Aid All Navy Bureaus

To meet the need for broad cooperation by industry on Navy problems concerning the use of plastics, the Navy Industrial Assn. Plastics Task Committee has been reorganized as a standing Plastics Advisory Committee.

The Task Committee originally was formed to study 27 specific plastics problems of the Bureau of Yards and Docks. Reports of the Committee's work for the Bureau of Yards and Docks which reached the office of Naval Material and other Bureaus of the Navy Department, resulted in the Association being asked to establish a permanent Plastics Advisory Committee that would service all interested Bureaus.

The reorganization meeting was held at the Navy Department recently and Rear Admiral C. E. Braine, Assistant Chief of Naval Material, reported that earlier accomplishments of the Plastics Task Committee gave promise that the expanded Committee could be of great usefulness to the entire Navy Department.

Admiral Braine also urged the Committee to stimulate industry into getting new products tested and placed on the accepted products list promptly. He stated that frequently new products are not offered until an emergency arises and that their use then is delayed pending necessary tests and time-consuming approvals.

NBS Announces Research Fellowships in Mathematics

The Institute for Numerical Analysis of the National Bureau of Standards, located at the University of California, Los Angeles, offers a number of research fellowships during the summer of 1949, and the academic year 1949-1950, to qualified graduate students in mathematics and mathematical physics. Fellows must be enrolled in an accredited college or university. Research work performed at the Institute can be applied toward a thesis for an advanced academic degree.

Fellows will work at the Institute and will be expected to perform mathematical research aimed at methods for advancing the applications of high speed automatic digital computing machinery. Individual work schedules can be arranged. Stipends will be based on full-time annual salaries of $2,294 for master's degree candidates and $3,727 for doctorate candidates.

Inquiries and requests for application forms should be addressed to the Chief, Institute for Numerical Analysis, 405 Hilgard Avenue, Los Angeles 24, California.

Engineering Societies Appeal For Collective Bargaining In New Labor Bill

The protection of design and other engineers subject to bargaining with employers was sought recently in hearings of the Senate Labor Committee. A plea for continuing in any new labor law the present Taft-Hartley provision granting bargaining protection to professional employees was made by a representative of seven engineering groups.

Professional employees should have the right to bargain collectively with their employers, but should not be subjected to "force grouping" of professional and non-professional employees, the Engineers Joint Council said in the Committee hearing. The statement asserted that "strict regimentation of professional employees is incompatible with the maintenance of true professional standards" and that there "should not be any submergence of the desires and interests of professional employees."

The Administration's bill now under consideration in Congress would return to the Wagner Act rules, under which separation of professional and non-professional in bargaining units of their own would be discretionary.

MEETINGS

May 10-13
AMERICAN MANAGEMENT ASSOCIATION—Eighteenth Annual Packaging Exposition, Convention Hall, Atlantic City, N. J.

May 19-21
SOCIETY FOR EXPERIMENTAL STRESS ANALYSIS—Spring Meeting, Hotel Statler, Detroit, Mich.

May 23-24
MAGNESIUM ASSOCIATION—Annual Meeting, Edgewater Beach Hotel, Chicago, Ill.

May 24-27
INSTITUTE OF AERONAUTICAL SCIENCES—Second Joint Meeting with Royal Aeronautical Society, Hotel Astor, New York, N. Y.

May 26-27
SOCIETY OF THE PLASTICS INDUSTRY—Annual Meeting, Edgewater Beach Hotel, Chicago, Ill.

June 5-10
SOCIETY OF AUTOMOTIVE ENGINEERS—Summer Meeting, French Lick Springs Hotel, French Lick, Ind.

June 20-24
AMERICAN SOCIETY FOR ENGINEERING EDUCATION—Annual Meeting, Rensselaer Polytechnic Institute, Troy, N. Y.

June 20-24
AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS—Summer General Meeting, New Ocean House, Swampscott, Mass.

June 27-30
AMERICAN ELECTROPLATERS' SOCIETY—Thirty-sixth Annual Convention, Schroeder Hotel, Milwaukee, Wis.

June 27-30
AMERICAN SOCIETY OF MECHANICAL ENGINEERS—Semi-Annual Meeting, University of California, San Francisco, Calif.

SAE Panel Meeting Accents Surface Finish

AN ALL-DAY PANEL SESSION on surface finish highlighted the SAE Passenger Car, Body and Production Meeting held March 8-10 at Detroit.

Production men told design engineers that the object of a surface specification is to describe the finish desired, not how to obtain it. They find it undesirable to use a symbol or means of dictating the type of finishing method on the drawing or specification to get the required finish. Maximum and minimum surface finish should be specified, to prevent a detrimental too-smooth or too-rough finish. They stated further that at present, designers find it best to specify surface finish for critical areas only. But it is possible that eventually readings for all surfaces will be shown on drawings.

Factors influencing surface finish, its effect on performance of parts and ways of measuring it were stressed.

Production men agreed that four basic factors affect surface finish:

1. Profile and irregularities of the tool itself.

2. Progression of the tool (speed of tool movement with respect to movement of the particular part that is being machined).

3. Built-up edge left by tool on surface, determined by the form of chip the tool cuts.

4. Tool chatter.

It was said that speed of dressing the grinding wheel and speed of the wheel driving operation can vary the roughness range. Experience has shown that while two groups of parts may be within the same roughness range, one group will have a longer life because of the different grinding speeds and wheel dressing speeds used.

Rough finish of a part promotes fast initial wear during operation, most engineers agreed. With a smooth finish between mating parts, clearance must be increased to insure correct final running clearance. By the same token, relatively rough mating parts require a reduced initial clearance to end up with the same final operating clearance after initial wearing as with smooth initial finish.

PRINCIPAL SPEAKERS at recent SAE surface finish symposium were: left to right, H. J. Griffing, Norton Co.; F. R. McFarland, Packard Motor Car Co.; C. R. Lewis, (Panel Leader) Chrysler Corp.; R. P. Trowbridge, Research Laboratories Div., GM Corp.; E. J. Abbott, Physicists Research Co.; and C. L. Stevens, Ford Motor Company.

Foreign Reports from McGraw-Hill World News

Three-Dimensional Screen For Television and Movies

A stereoscopic screen for cinematographic projection and television receivers has been developed in Sydney, Australia. Mr. E. G. Beard, the inventor, is head of the patent department of the Australian branch plant of Philips, a Dutch electrical and radio concern.

To obtain a three-dimensional view of screen images it is necessary to project two stereoscopic pictures onto the screen and to provide some means whereby each member of a large audience sees only one of the two pictures.

The Beard screen, in its simplest form, consists of a polished metal sheet engraved with overlapping sets of concentric circles drawn on centers that are in line with rows of observers, as in a movie audience. The grooves, being of semicircular cross section, act as concave mirrors which reflect the two images at the correct angle to the observer. Alternatively, the screen can be formed of overlapping sets of concentric circles in the shape of ridges of semicircular wire. In either case, all portions of the screen, except the flat portions between the grooves or ridges, consist of sections through an infinite number of spherical reflectors. The pattern of ridges or grooves on the screen is based on complex optical-mathematical calculations.

Ordinary movie cameras can be used to take stereoscopic pictures if a system of prisms is placed in front of the lens to split the image into halves, each representing the view from a slightly different position. The projector is modified in a similar manner.

To date, several experimental screens for cinematographic projection have been successfully demonstrated in Australia. It is believed that stereoscopic pictures could be televised without loss of detail and increase in band width by use of interlaced scanning, the first scanning to transmit the view for one eye, and the second, the view for the other. Any of the well-known switching systems for showing two sets of phenomena on the screen of a single oscilloscope can be used for dividing the two pictures.

Two Strippable Plastic Coatings Leave Lubricating Film

Two Strippable Plastic Coatings vention, Crocell and Lowerite, have recently been developed by Croda Limited, Snaith, Goole, Yorkshire, England. Both materials are applied by dipping—Crocell at 160 to 185 C; Lowerite at room temperature. In either case, the coating can be stripped off in one piece, leaving a film of pure lubricating oil extruded from the film during storage.

Crocell, a tough, thick, thermoplastic skin, is impervious to most forms of corrosion and provides a partial cushion that protects the coated part from knocks and abrasions during storage and transport.

The Lowerite coating is a transparent, tough, elastic and continuous membrane. It is also supplied in such colors as red, green and blue, which, apart from insuring complete coverage, provide an attractive finish. Identification marks on tools, gears and other parts can easily be read through the film, whether plain or colored.

yes... an oil seal that's tailor-made to *resist* corrosion

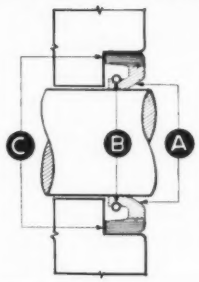
● If corrosive conditions are shortening the life of your oil seals, the Johns-Manville Clipper Seal should provide a practical solution to your problem.

Here's why: The Clipper Seal's molded body is entirely non-metallic and is, therefore, unaffected by most forms of corrosion. To meet special conditions, the garter spring which holds the lip in contact with the shaft can be furnished in various corrosion-resistant metals . . . *or Clipper Seals of special design that do not require garter springs may be used.*

The one-piece, concentric molded design of Clipper Seals also assures a number of other advantages. The hard, tough outer heel of the Clipper Seal is resilient enough to conform even to a slightly out-of-round cavity. And the soft, pliable inner lip always maintains a light, but positive sealing pressure on the shaft, with minimum wear on the seal.

Clipper Seals are quick and easy to install, may be had in split or endless types, are available in sizes from ¼" I.D. up to 66" O.D. If you have a special sealing requirement, or wish to consult about a special design problem, write Johns-Manville, Box 290, New York 16, N. Y.

Here's how *Clipper Seal* works:



The flexible lip (A) is held in light but firm contact with the shaft by means of the garter spring (B). Pressure on shaft is carefully pre-determined to minimize wear, yet effectively seal against leakage. The rigid heel (C) provides a press fit in the cavity, assuring a tight lubricant-retaining seal at this point also.

Johns-Manville **PACKINGS & GASKETS**

Piston-Crank Position Factors

ALEXANDER HAMMER
Analytical Engineer, De Laval Steam Turbine Company

THE ACCOMPANYING TABLE gives values of a factor f_c for determining the position of the crosshead or piston corresponding to a crank angle position in a slider crank mechanism.

r = crank radius, in.
l = connecting rod length, in.
$k = l/r$ = ratio of length of connecting rod to radius of crank
θ = crank position from head end dead center, deg.
f_c = factor from accompanying table for specific k and crank angle θ
x = displacement of piston from position at head end dead center, in.

It is obvious from the accompanying figure that

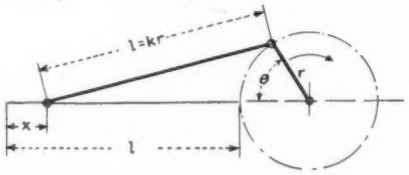
$$x = l + r - r\cos\theta - \sqrt{l^2 - r^2\sin^2\theta}$$

$$= kr + r - r\cos\theta - \sqrt{k^2r^2 - r^2\sin^2\theta}$$

$$= r\,(k + 1 - \cos\theta - \sqrt{k^2 - \sin^2\theta})$$

$$f_c = (k + 1 - \cos\theta - \sqrt{k^2 - \sin^2\theta})$$

$$x = rf_c$$



Values of f_c are given in the accompanying table for k ratios ranging from 3.0 to 5.0.

PROBLEM: Find position of piston from head end dead center when crank radius is 3 in., connecting rod length is 12.6 in., and crank angle is 40 deg from head end dead center?

SOLUTION:

$l = 12.6$, $r = 3$, $k = l/r = 12.6/3 = 4.2$

From table, for k equal to 4.2 and θ equal to 40 deg, f_c is 0.2834

Then,

$x = rf_c = 3 \times 0.2834 = 0.8502$ in.

Values of f_c

Crank angle deg.	Ratio of Length of Rod to Length of Crank $l/r = k$																				
	3.0	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	4.0	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	5.0
0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
5	0.0051	0.0050	0.0050	0.0050	0.0049	0.0049	0.0049	0.0048	0.0048	0.0048	0.0048	0.0047	0.0047	0.0047	0.0047	0.0047	0.0046	0.0046	0.0046	0.0046	0.0046
10	0.0202	0.0201	0.0199	0.0198	0.0196	0.0195	0.0194	0.0193	0.0192	0.0191	0.0190	0.0189	0.0188	0.0187	0.0186	0.0185	0.0184	0.0183	0.0183	0.0183	0.0182
15	0.0453	0.0449	0.0446	0.0443	0.0440	0.0437	0.0434	0.0431	0.0429	0.0427	0.0425	0.0423	0.0421	0.0419	0.0417	0.0415	0.0414	0.0412	0.0411	0.0409	0.0408
20	0.0799	0.0792	0.0786	0.0781	0.0776	0.0771	0.0766	0.0762	0.0757	0.0753	0.0750	0.0746	0.0743	0.0739	0.0736	0.0733	0.0730	0.0728	0.0725	0.0723	0.0720
25	0.1236	0.1226	0.1217	0.1209	0.1201	0.1193	0.1186	0.1179	0.1173	0.1167	0.1161	0.1155	0.1150	0.1146	0.1140	0.1136	0.1132	0.1127	0.1123	0.1120	0.1116
30	0.1759	0.1746	0.1733	0.1721	0.1709	0.1699	0.1689	0.1679	0.1670	0.1662	0.1653	0.1646	0.1638	0.1631	0.1625	0.1618	0.1612	0.1606	0.1601	0.1596	0.1590
35	0.2362	0.2344	0.2327	0.2311	0.2296	0.2282	0.2268	0.2256	0.2244	0.2233	0.2222	0.2212	0.2202	0.2193	0.2184	0.2176	0.2168	0.2160	0.2152	0.2145	0.2139
40	0.3036	0.3013	0.2992	0.2972	0.2953	0.2935	0.2918	0.2902	0.2887	0.2873	0.2860	0.2847	0.2834	0.2823	0.2812	0.2801	0.2791	0.2781	0.2772	0.2763	0.2755
45	0.3774	0.3746	0.3720	0.3695	0.3672	0.3651	0.3630	0.3611	0.3593	0.3575	0.3559	0.3543	0.3528	0.3514	0.3501	0.3488	0.3476	0.3464	0.3453	0.3442	0.3431
50	0.4567	0.4534	0.4503	0.4474	0.4446	0.4421	0.4397	0.4374	0.4352	0.4332	0.4313	0.4294	0.4277	0.4260	0.4244	0.4229	0.4214	0.4201	0.4187	0.4175	0.4162
55	0.5404	0.5366	0.5330	0.5297	0.5266	0.5236	0.5209	0.5182	0.5158	0.5134	0.5112	0.5091	0.5071	0.5052	0.5033	0.5016	0.4999	0.4984	0.4968	0.4954	0.4940
60	0.6277	0.6234	0.6194	0.6157	0.6121	0.6088	0.6057	0.6028	0.6000	0.5974	0.5949	0.5925	0.5903	0.5881	0.5861	0.5841	0.5823	0.5805	0.5788	0.5771	0.5756
65	0.7176	0.7128	0.7084	0.7043	0.7004	0.6968	0.6933	0.6901	0.6870	0.6842	0.6814	0.6788	0.6763	0.6740	0.6717	0.6696	0.6676	0.6656	0.6637	0.6619	0.6602
70	0.8090	0.8038	0.7991	0.7946	0.7904	0.7865	0.7828	0.7793	0.7760	0.7729	0.7699	0.7671	0.7645	0.7619	0.7595	0.7572	0.7550	0.7529	0.7509	0.7489	0.7471
75	0.9009	0.8955	0.8904	0.8857	0.8813	0.8771	0.8732	0.8695	0.8660	0.8627	0.8596	0.8566	0.8538	0.8511	0.8485	0.8461	0.8437	0.8415	0.8394	0.8373	0.8354
80	0.9926	0.9869	0.9817	0.9767	0.9721	0.9678	0.9637	0.9598	0.9562	0.9527	0.9495	0.9464	0.9434	0.9406	0.9380	0.9354	0.9330	0.9307	0.9285	0.9263	0.9243
85	1.0831	1.0773	1.0719	1.0668	1.0621	1.0576	1.0534	1.0495	1.0458	1.0422	1.0389	1.0357	1.0327	1.0298	1.0271	1.0245	1.0220	1.0196	1.0174	1.0152	1.0131
90	1.1716	1.1657	1.1603	1.1552	1.1504	1.1459	1.1417	1.1377	1.1339	1.1304	1.1270	1.1238	1.1208	1.1179	1.1151	1.1125	1.1100	1.1076	1.1053	1.1031	1.1010
95	1.2574	1.2516	1.2462	1.2411	1.2364	1.2319	1.2277	1.2238	1.2201	1.2165	1.2132	1.2100	1.2070	1.2041	1.2014	1.1988	1.1963	1.1939	1.1917	1.1895	1.1874
100	1.3399	1.3342	1.3290	1.3240	1.3194	1.3151	1.3110	1.3071	1.3035	1.3000	1.2968	1.2937	1.2907	1.2879	1.2853	1.2827	1.2803	1.2780	1.2758	1.2736	1.2716
105	1.4186	1.4132	1.4081	1.4034	1.3989	1.3948	1.3908	1.3871	1.3836	1.3803	1.3772	1.3742	1.3714	1.3687	1.3662	1.3637	1.3614	1.3592	1.3570	1.3550	1.3530
110	1.4930	1.4879	1.4831	1.4786	1.4745	1.4705	1.4668	1.4633	1.4600	1.4569	1.4540	1.4512	1.4485	1.4460	1.4435	1.4412	1.4390	1.4369	1.4349	1.4330	1.4311
115	1.5628	1.5581	1.5537	1.5495	1.5456	1.5420	1.5386	1.5353	1.5323	1.5294	1.5267	1.5241	1.5216	1.5192	1.5170	1.5148	1.5128	1.5108	1.5090	1.5072	1.5055
120	1.6277	1.6234	1.6194	1.6157	1.6121	1.6088	1.6057	1.6028	1.6000	1.5974	1.5949	1.5925	1.5903	1.5881	1.5861	1.5841	1.5823	1.5805	1.5788	1.5771	1.5756
125	1.6876	1.6838	1.6802	1.6769	1.6737	1.6708	1.6680	1.6654	1.6629	1.6606	1.6584	1.6562	1.6542	1.6523	1.6505	1.6488	1.6471	1.6455	1.6440	1.6425	1.6411
130	1.7422	1.7389	1.7358	1.7329	1.7302	1.7277	1.7252	1.7230	1.7208	1.7188	1.7168	1.7150	1.7132	1.7116	1.7100	1.7085	1.7070	1.7056	1.7043	1.7030	1.7018
135	1.7916	1.7888	1.7862	1.7838	1.7815	1.7793	1.7772	1.7753	1.7735	1.7718	1.7701	1.7686	1.7671	1.7657	1.7643	1.7630	1.7618	1.7606	1.7595	1.7584	1.7574
140	1.8357	1.8334	1.8313	1.8293	1.8274	1.8256	1.8239	1.8223	1.8208	1.8194	1.8180	1.8167	1.8155	1.8144	1.8133	1.8122	1.8112	1.8102	1.8093	1.8084	1.8075
145	1.8745	1.8727	1.8710	1.8694	1.8679	1.8665	1.8651	1.8639	1.8627	1.8616	1.8605	1.8595	1.8585	1.8576	1.8567	1.8559	1.8551	1.8543	1.8535	1.8528	1.8522
150	1.9080	1.9066	1.9053	1.9041	1.9030	1.9019	1.9009	1.9000	1.8991	1.8982	1.8974	1.8966	1.8959	1.8952	1.8945	1.8939	1.8933	1.8927	1.8921	1.8916	1.8911
155	1.9362	1.9353	1.9343	1.9335	1.9327	1.9319	1.9312	1.9305	1.9299	1.9293	1.9287	1.9282	1.9276	1.9271	1.9267	1.9262	1.9258	1.9254	1.9250	1.9246	1.9242
160	1.9593	1.9586	1.9580	1.9575	1.9569	1.9564	1.9560	1.9555	1.9551	1.9547	1.9543	1.9540	1.9536	1.9533	1.9530	1.9527	1.9524	1.9522	1.9519	1.9516	1.9514
165	1.9771	1.9767	1.9764	1.9761	1.9758	1.9755	1.9752	1.9750	1.9747	1.9745	1.9743	1.9741	1.9739	1.9737	1.9735	1.9734	1.9732	1.9731	1.9729	1.9728	1.9726
170	1.9898	1.9897	1.9895	1.9894	1.9893	1.9891	1.9890	1.9889	1.9888	1.9887	1.9886	1.9885	1.9884	1.9883	1.9882	1.9882	1.9881	1.9880	1.9880	1.9879	1.9878
175	1.9975	1.9974	1.9974	1.9973	1.9973	1.9973	1.9973	1.9972	1.9972	1.9972	1.9971	1.9971	1.9971	1.9971	1.9971	1.9970	1.9970	1.9970	1.9970	1.9970	1.9970
180	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000

AUTO-LITE *announces...*

Tune in "Suspense!" — CBS Radio Network Thursdays, CBS Television Tuesdays.

The new Auto-Lite plant at Lockland, Ohio, one of the largest manufacturing plants in the world, devotes a part of its 3,500,000 square feet of floor space to precision die casting.

Increased production facilities for

DIE CASTINGS

● **Here is important news for everyone who has need of the accurate, reliable die castings made possible with the famous Auto-Lite "controlled metals" processes. The opening of the great new Lockland plant of Auto-Lite, combined with the enlarged facilities at Woodstock, Illinois, greatly increases Auto-Lite's ability to furnish the high quality die castings for which the Auto-Lite name is known wherever die castings are used. We invite your inquiries.**

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Die Casting Division, Woodstock, Illinois
600 S. Michigan Avenue, Chicago 5, Illinois
723 New Center Bldg., Detroit 2, Michigan

Torque Factors for Slider Crank Mechanism

ALEXANDER HAMMER
Analytical Engineer, De Laval Steam Turbine Company

THE ACCOMPANYING TABLE gives values of a factor f_t for determining torque imposed on a crankshaft by a force acting on a crosshead in the direction of stroke.

P = force on piston or crosshead, lb.
θ = crank position, from head end dead center, deg
β = connecting rod angle corresponding to θ, deg
P_t = force on connecting rod, lb
$P_t = P/\cos\beta$, lb
l = connecting rod length, in.
r = crank radius, in.
$k = l/r$ = ratio of length of connecting rod to radius of crank
a = perpendicular distance from centerline of connecting rod to center of crank shaft, in.
$a = r \sin(\theta + \beta)$, in.
T = torque on crankshaft, lb in.
f_t = factor from accompanying table for specific k and crank angle θ
$T = P_t a = (P/\cos\beta)\, r \sin(\theta + \beta)$

$$= Pr\left[\frac{\sin\theta\cos\beta + \cos\theta\sin\beta}{\cos\beta}\right] \quad (1)$$

since $\frac{r}{kr} = \frac{\sin\beta}{\sin\theta}$, then $\sin\beta = \frac{\sin\theta}{k}$

and $\sqrt{1-\cos^2\beta} = \sin\theta/k$

or $\cos\beta = \sqrt{k^2 - \sin^2\theta}/k$

substituting these values of $\sin\beta$ and $\cos\beta$ in Eq (1), there results

$$T = Pr\left[\sin\theta\left(1 + \frac{\cos\theta}{\sqrt{k^2 - \sin^2\theta}}\right)\right] \quad (2)$$

substituting f_t for the expression contained in the brackets of Eq (2), there results

$$T = Prf_t \quad (3)$$

Values of f_t are given in the accompanying table for k ratios ranging from 3.0 to 5.0.

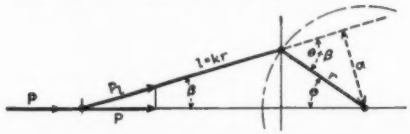
PROBLEM: Find torque on crankshaft resulting from a force of 150 lb on crosshead, when crank radius is 3 in., connecting rod length is 12.6 in., and crank angle is 40 deg from head end dead center?

SOLUTION:

$l = 12.6$, $r = 3$, $k = l/r = 12.6/3 = 4.2$

From Table, for k equal to 4.2 and θ equal to 40 deg, f_t is 0.7614, then

$T = Prf_t = 150 \times 3 \times 0.7614 = 342.63$ lb in.



Tangential Factors f_t

Crank angle deg.	Ratio of Length of Rod to Length of Crank $l/r = k$																				
	3.0	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	4.0	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	5.0
0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
5	0.1161	0.1152	0.1143	0.1135	0.1127	0.1120	0.1113	0.1106	0.1100	0.1094	0.1089	0.1083	0.1078	0.1073	0.1069	0.1064	0.1060	0.1056	0.1052	0.1049	0.1045
10	0.2308	0.2289	0.2272	0.2255	0.2240	0.2226	0.2212	0.2199	0.2187	0.2175	0.2164	0.2154	0.2144	0.2135	0.2125	0.2117	0.2109	0.2101	0.2093	0.2086	0.2079
15	0.3425	0.3397	0.3372	0.3348	0.3326	0.3304	0.3284	0.3266	0.3248	0.3231	0.3215	0.3199	0.3185	0.3171	0.3157	0.3145	0.3133	0.3121	0.3110	0.3099	0.3089
20	0.4499	0.4463	0.4430	0.4399	0.4370	0.4343	0.4317	0.4293	0.4269	0.4247	0.4227	0.4207	0.4188	0.4170	0.4153	0.4136	0.4121	0.4106	0.4091	0.4078	0.4064
25	0.5516	0.5473	0.5434	0.5397	0.5362	0.5329	0.5298	0.5268	0.5240	0.5214	0.5189	0.5165	0.5143	0.5121	0.5101	0.5081	0.5062	0.5044	0.5027	0.5011	0.4995
30	0.6464	0.6415	0.6370	0.6328	0.6288	0.6250	0.6215	0.6181	0.6150	0.6120	0.6091	0.6064	0.6038	0.6014	0.5991	0.5968	0.5947	0.5927	0.5907	0.5888	0.5870
35	0.7331	0.7278	0.7228	0.7182	0.7138	0.7097	0.7058	0.7021	0.6987	0.6954	0.6923	0.6893	0.6865	0.6838	0.6813	0.6788	0.6765	0.6743	0.6722	0.6701	0.6682
40	0.8108	0.8052	0.7999	0.7949	0.7903	0.7859	0.7818	0.7779	0.7743	0.7708	0.7675	0.7644	0.7614	0.7586	0.7559	0.7533	0.7509	0.7486	0.7463	0.7442	0.7421
45	0.8786	0.8728	0.8673	0.8622	0.8575	0.8530	0.8488	0.8448	0.8410	0.8375	0.8341	0.8309	0.8279	0.8250	0.8222	0.8196	0.8171	0.8147	0.8124	0.8102	0.8081
50	0.9358	0.9300	0.9245	0.9194	0.9147	0.9102	0.9060	0.9021	0.8983	0.8948	0.8915	0.8883	0.8853	0.8824	0.8797	0.8771	0.8746	0.8722	0.8700	0.8678	0.8657
55	0.9820	0.9763	0.9710	0.9661	0.9615	0.9572	0.9532	0.9494	0.9458	0.9424	0.9392	0.9361	0.9332	0.9305	0.9278	0.9253	0.9230	0.9207	0.9185	0.9164	0.9144
60	1.0168	1.0115	1.0066	1.0020	0.9977	0.9937	0.9900	0.9864	0.9831	0.9799	0.9769	0.9741	0.9714	0.9688	0.9664	0.9641	0.9619	0.9598	0.9577	0.9558	0.9540
65	1.0402	1.0355	1.0311	1.0270	1.0232	1.0196	1.0162	1.0131	1.0101	1.0073	1.0046	1.0021	0.9997	0.9974	0.9953	0.9932	0.9912	0.9894	0.9876	0.9859	0.9842
70	1.0525	1.0485	1.0448	1.0413	1.0380	1.0350	1.0322	1.0295	1.0270	1.0246	1.0224	1.0202	1.0182	1.0163	1.0145	1.0127	1.0111	1.0095	1.0080	1.0065	1.0051
75	1.0539	1.0508	1.0479	1.0451	1.0426	1.0402	1.0380	1.0359	1.0339	1.0321	1.0303	1.0287	1.0271	1.0256	1.0242	1.0228	1.0215	1.0203	1.0191	1.0180	1.0169
80	1.0452	1.0430	1.0410	1.0391	1.0374	1.0357	1.0342	1.0328	1.0314	1.0301	1.0289	1.0278	1.0267	1.0257	1.0247	1.0238	1.0229	1.0220	1.0212	1.0204	1.0197
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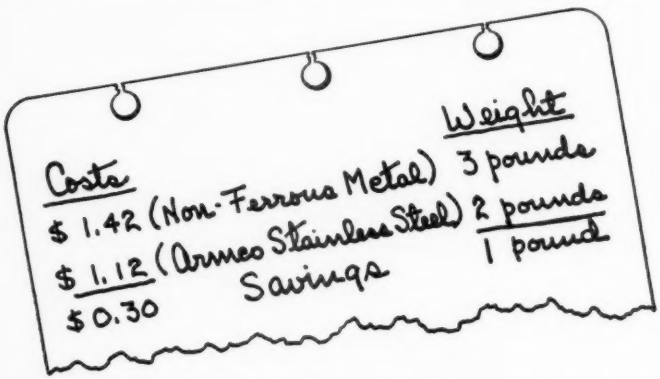
90	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
95	0.9655	0.9666	0.9676	0.9686	0.9695	0.9703	0.9711	0.9718	0.9725	0.9732	0.9738	0.9744	0.9749	0.9754	0.9759	0.9764	0.9769	0.9773	0.9777	0.9781	0.9785
100	0.9245	0.9266	0.9286	0.9305	0.9323	0.9339	0.9354	0.9369	0.9382	0.9395	0.9407	0.9418	0.9429	0.9440	0.9449	0.9459	0.9468	0.9476	0.9484	0.9492	0.9499
105	0.8779	0.8810	0.8840	0.8867	0.8892	0.8916	0.8938	0.8959	0.8979	0.8998	0.9015	0.9032	0.9048	0.9063	0.9077	0.9090	0.9103	0.9116	0.9127	0.9139	0.9150
110	0.8269	0.8309	0.8346	0.8381	0.8413	0.8444	0.8472	0.8499	0.8524	0.8548	0.8570	0.8592	0.8612	0.8631	0.8649	0.8667	0.8683	0.8699	0.8714	0.8729	0.8742
115	0.7724	0.7771	0.7815	0.7856	0.7894	0.7930	0.7964	0.7995	0.8025	0.8053	0.8080	0.8105	0.8129	0.8152	0.8174	0.8194	0.8214	0.8233	0.8251	0.8268	0.8284
120	0.7153	0.7206	0.7255	0.7300	0.7343	0.7383	0.7421	0.7457	0.7490	0.7522	0.7551	0.7580	0.7607	0.7632	0.7657	0.7680	0.7702	0.7723	0.7743	0.7762	0.7781
125	0.6563	0.6620	0.6673	0.6722	0.6768	0.6811	0.6851	0.6889	0.6925	0.6959	0.6991	0.7022	0.7051	0.7078	0.7105	0.7130	0.7154	0.7176	0.7198	0.7219	0.7239
130	0.5963	0.6021	0.6076	0.6126	0.6174	0.6219	0.6261	0.6300	0.6337	0.6373	0.6406	0.6438	0.6468	0.6497	0.6524	0.6550	0.6575	0.6599	0.6621	0.6643	0.6664
135	0.5356	0.5415	0.5469	0.5520	0.5568	0.5612	0.5655	0.5694	0.5732	0.5767	0.5801	0.5833	0.5863	0.5892	0.5920	0.5946	0.5971	0.5995	0.6018	0.6040	0.6061
140	0.4748	0.4804	0.4857	0.4907	0.4953	0.4997	0.5038	0.5077	0.5113	0.5148	0.5181	0.5212	0.5242	0.5270	0.5297	0.5322	0.5347	0.5370	0.5393	0.5414	0.5435
145	0.4140	0.4194	0.4243	0.4290	0.4334	0.4375	0.4414	0.4450	0.4485	0.4518	0.4549	0.4578	0.4607	0.4633	0.4659	0.4683	0.4705	0.4729	0.4750	0.4770	0.4790
150	0.3536	0.3585	0.3630	0.3673	0.3712	0.3750	0.3785	0.3819	0.3850	0.3880	0.3909	0.3936	0.3962	0.3986	0.4009	0.4032	0.4053	0.4073	0.4093	0.4112	0.4130
155	0.2937	0.2979	0.3019	0.3056	0.3091	0.3124	0.3155	0.3184	0.3212	0.3238	0.3263	0.3287	0.3310	0.3331	0.3352	0.3371	0.3390	0.3408	0.3425	0.3442	0.3457
160	0.2342	0.2377	0.2410	0.2441	0.2470	0.2498	0.2523	0.2548	0.2571	0.2593	0.2614	0.2634	0.2652	0.2670	0.2688	0.2704	0.2720	0.2735	0.2749	0.2763	0.2776
165	0.1752	0.1779	0.1804	0.1828	0.1851	0.1872	0.1892	0.1911	0.1929	0.1946	0.1962	0.1977	0.1992	0.2006	0.2019	0.2032	0.2044	0.2055	0.2067	0.2077	0.2088
170	0.1166	0.1184	0.1201	0.1218	0.1233	0.1247	0.1261	0.1274	0.1286	0.1298	0.1309	0.1319	0.1329	0.1338	0.1348	0.1356	0.1364	0.1372	0.1380	0.1387	0.1394
175	0.0582	0.0591	0.0600	0.0608	0.0616	0.0623	0.0630	0.0637	0.0643	0.0649	0.0654	0.0660	0.0665	0.0670	0.0674	0.0679	0.0683	0.0687	0.0691	0.0694	0.0698
180	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

STAINLESS SAVES 21%

on this Perforated Strainer Pan



This cost/weight analysis tells the story of how another company changed to ARMCO Stainless to *cut costs* and provide their customers with a better product!

These perforated strainers for all-Stainless Steel commercial dishwashers were formerly made of a 14-gage non-ferrous metal. Now they're 18-gage Type 302 ARMCO Stainless Steel —one pound lighter because 18 gage Stainless is stronger than the 14 gage metal it replaced.

The total saving in material and fabricating costs is 30 cents or 21% on each pan. As many as 10 strainers are required for large washers.

Users are elated with the new Stainless pan. It doesn't damage easily in rough handling, and the center handle *stays on*. Corrosion resistance is much better because ARMCO Stainless is not affected by commercial detergents. (Replacements were formerly the rule because chemicals in these cleaners caused corrosion of the non-ferrous metal).

Using ARMCO Stainless Steels to *cut first-cost* and improve products or equipment is nothing new; it may be possible in your business too. So why not take the first important step today by analyzing *your* finished product costs using this rustless steel. ARMCO Engineers will be glad to talk it over.

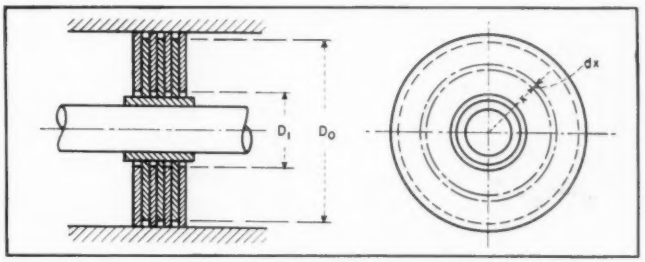
Just address Armco Steel Corporation, 147 Curtis St., Middletown, Ohio.

ARMCO STAINLESS STEELS

ARMCO

Accurate Solution for Disk-Clutch Torque Capacity

NILS M. SVERDRUP
Development Engineer,
AiResearch Manufacturing Company



IN COMPUTING TORQUE CAPACITY, the mean radius R of the clutch disks is often used. The torque equation then assumes the following form:

$$T = P\mu Rn \quad (1)$$

Where

T = torque, in.-lb
P = pressure, lb.
μ = coefficient of friction
R = mean radius of disks, in.
n = no. of friction surfaces

This formula, however, is not mathematically correct and should be used cautiously. The formula's accuracy varies with the ratio D_i/D_o. When D_i/D_o approaches unity, the error is negligible; but as the value of this ratio decreases, the induced error will increase to a maximum of 33 percent.

By introducing a correction factor, ϕ, Eq (1) can be written

$$T = P\mu Rn\phi \quad (2)$$

The value of the correction factor can be derived by the calculus derivation of Eq (2).

Sketch above represents a disk clutch with n friction surfaces, pressure between plates being p psi. Inside and outside diameters of effective friction areas are D_i and D_o in:, respectively. Since the magnitude of pressure on an element of area, dA, at distance x from center is pdA, the friction force is $pdA\mu$ and the moment of this force around the center is $pdA\mu x$.

Integrating within limits $D_i/2$ and $D_o/2$ and multiplying by n friction surfaces, the expression for total torque in in.-lb is obtained.

Hence

$$T = \int_{D_i/2}^{D_o/2} pdA\mu xn \quad (3)$$

but

$$dA = 2\pi x dx \quad (4)$$

Substituting in Eq (3)

$$T = \int_{D_i/2}^{D_o/2} p\,(2\pi x dx)\,\mu xn$$

$$= (2/3)\pi p\mu n\left[\left(\frac{D_o}{2}\right)^3 - \left(\frac{D_i}{2}\right)^3\right]$$

or $$T = 0.262\,p\mu n\,(D_o^3 - D_i^3) \quad (5)$$

If the total pressure acting on clutch disks be P lb, the expression for pressure per unit area is

$$p = \frac{P}{(\pi/4)\,(D_o^2 - D_i^2)}$$

Substituting this value for p in Eq (5)

$$T = 0.333\,P\mu n\,\frac{D_o^2 + D_o D_i + D_i^2}{D_o + D_i} \quad (6)$$

Now let

$$\frac{D_i}{D_o} = m \text{ so that, } D_i = m\,D_o \quad (7)$$

Substituting in Eq (6)

$$T = 0.333\,P\mu n D_o\,\frac{1 + m^2 + m}{1 + m} \quad (8)$$

Similarly, by substituting value of D_i from Eq (7) in Eq (2), and having

$$R = \frac{D_o + D_i}{4},$$

$$T = P\mu\,\frac{D_o + m\,D_o}{4}\,n\phi$$

or

$$T = 0.25\,P\mu n\phi\,D_o\,(1 + m) \quad (9)$$

Equating expressions (8) and (9)

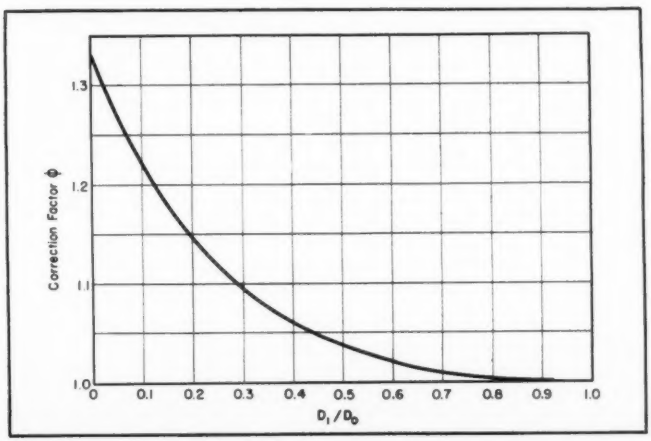
$$0.25\,P\mu n\phi\,D_o\,(1 + m) =$$

$$0.333\,P\mu n\,D_o\,\frac{1 + m^2 + m}{1 + m}$$

and solving for ϕ, the result is

$$\phi = 1.333 \times \frac{1 + m^2 + m}{(1 + m)^2} \quad (10)$$

With various diameter ratios, the values for ϕ were computed and represented in graph herewith. By using this graph and Eq (2), accurate values of torque can be easily determined.



The weight's in the load and not in the truck when frames, body panels, fenders, wheels and other truck structural parts are made of N-A-X HIGH-TENSILE. And while affording weight savings of up to 25% in section, the high physical properties of N-A-X HIGH-TENSILE insure superior strength and increased resistance to fatigue, corrosion, abrasion and denting.

This decrease in deadweight decreases on-the-job expenses, too. Trucks built with N-A-X HIGH-TENSILE consume less gasoline . . . require less maintenance . . . give longer service. And the excellent formability, weldability, and fine surface texture of N-A-X HIGH-TENSILE mean that you build them better, with no added fabricating problems.

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Specify—
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HIGH-TENSILE STEEL

GREAT LAKES STEEL CORPORATION N-A-X ALLOY DIVISION • DETROIT 18, MICHIGAN
Unit of National Steel Corporation

NEW MATERIALS AND PARTS

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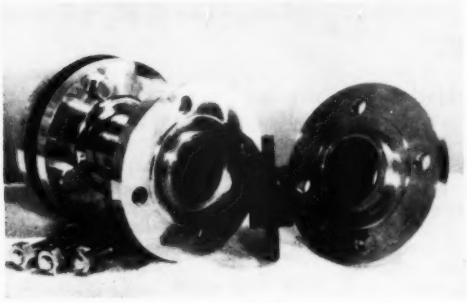
Pipe Joints

Gates Engineering Co., New Castle Ave., New Castle, Del.

Rubber-lined pipe joints make it possible to join two sections of rubber-lined pipe without the use of welded flanges. Counterbored and grooved pipe ends fit rubber



seals which will resist leakage with pressures up to 1,300 psi. Flanges fitting over these seals are separated by a hard flexible rubber insert that will withstand temperatures up to 212 F. This insert, as shown, is inert to almost all acids and alkalies. Joints can be used with welded-on or screwed-on pipe flanges already in use. These fittings, known as Gaco Joints, are available in ½ to 4 in. pipe sizes as 45 deg, 90 deg, Y's, Tees and separate flange kits for connecting straight lengths.

Solenoid Control Valves

Vickers Inc., 1454 Oakman Blvd., Detroit, Mich.

Series DG solenoid controlled 2, 3 and 4-way valves are available with pipe sizes from ⅛ to 1¼ in. The smallest size valves are furnished with solenoids for 110 v., 25, 50 or 60 cycle service. Rated capacity is 1.2 gpm and inrush current is 3 amp. The 1¼ in. size has the same solenoid ratings as the former, but the rated capacity is 50 gpm. Designed for gasket mounting, valve sub-

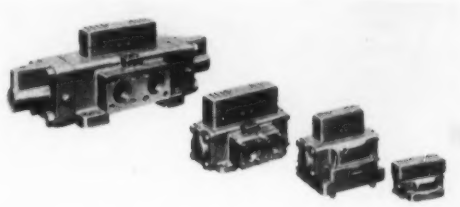
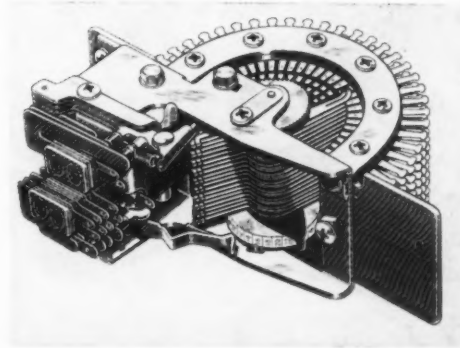


plate also has threaded female connections for in-line hook up. With gasket mounted installations, "O" rings are used to provide a positive seal which will withstand up to 2,000 psi pressure.

Spring-Driven Switch

C. P. Clare & Co., 4719 Sunnyside Ave., Chicago, Ill.

Switch can have from 1 to 10 bank levels each having 26 contacts. A pair of double-ended wiper springs is stepped over each bank level; one end of the wipers is always free of the bank contacts while the other end is in contact with the bank. By stepping through 180 deg

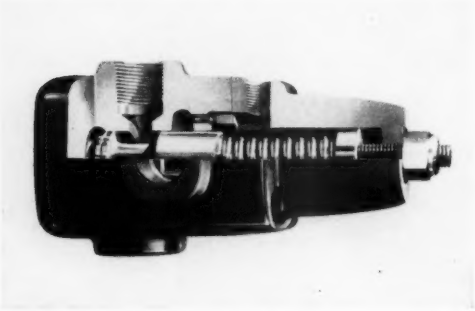


each end of the wipers steps successively over all contacts. Stepping magnet can be remotely controlled, or wipers can be caused to step automatically by interrupting the magnet circuit. Switch will operate at a maximum of 30 steps per second in remote control, while self-controlled operation is at an average of 60 steps per second with 48 v power supply. Dimensions are about 6 $\frac{1}{2}$ x 2 $\frac{3}{8}$ x 4 $\frac{5}{8}$ inches.

Hydraulic Relief Valve

Gerotor May Corp., P. O. Box 86, Baltimore 3, Md.

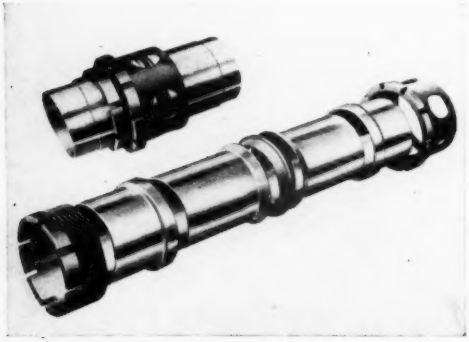
Designed to protect hydraulic systems against damage from pressure overloads, valve contains dash-pot arrangement which stops chatter. In-line piping is made possible by pressure ports, and valve springs are available in two sizes for operation with pressures from 50 to 500 and 50 to 1,500 psi. Other parts include "O" ring seal, self-sealing locknut and a single diameter cylinder bore to insure accurate plunger fitting.

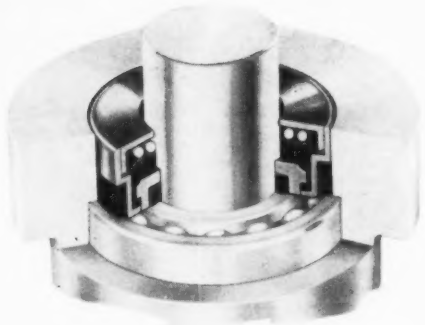


Flared Tube Unions

Roylyn Inc., 718 W. Wilson Ave., Glendale 3, Cal.

Series 1900 unions for joining flared tubing are designed as lightweight connections for fluid lines. The unions consist of a metal seal ring, two sleeves, a threaded clamp ring and a mating coupling nut. The coupling nut has visual inspection ports. These unions are available in 1$\frac{1}{2}$, 2, 2$\frac{1}{2}$, 3 and 4 in. sizes, in either steel or aluminum alloy construction.





Shaft Seal

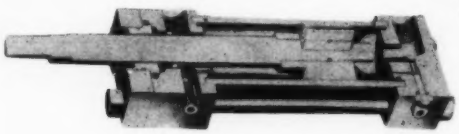
Gits Bros. Mfg. Co., 1846 S. Kilbourn Ave., Chicago 23, Ill.

Seal, designed for horizontal and vertical rotating shafts, has both rotating and stationary surfaces built inside a metal cartridge. The major components of the seal are the stationary seal ring, diaphragm, spring assembly and the rotating seal ring. The latter contains a resilient gasket which is frictionally held against inner race of ball bearing assembly or shaft shoulder. A spring keeps the seal tight if there is vibration or shaft misalignment, or if wear rubs away seal faces. Shaft seals are made to fit $\frac{1}{4}$ to 2$\frac{1}{4}$ in. shafts.

Hydraulic Cylinders

Miller Motor Co., 4027 N. Kedzie Ave., Chicago 18, Ill.

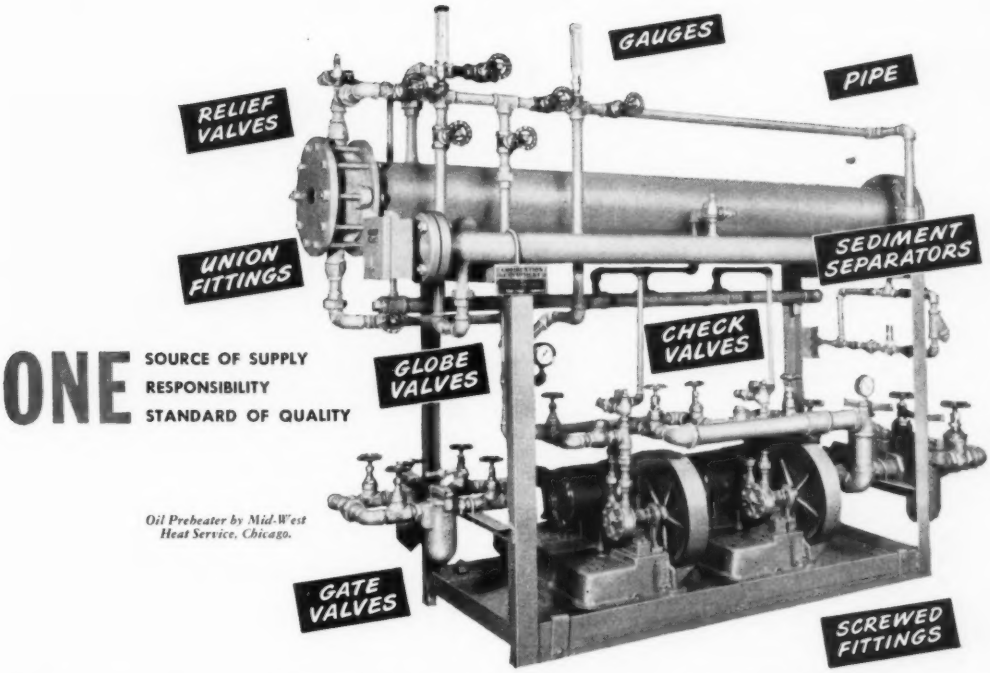
Standard 10 and 12 in. bore hydraulic cylinders are available in single and double rod end models which will operate at pressures up to 2,500 or 3,500 psi. Cylinders can be made with various piston and piston rod seals for different applications. Design includes a cylinder, bushing and piston "O" ring seals, cushion check adjusting screws, and air bleeds when specified. Assemblies have steel heads, caps, and mountings, hard chrome plated piston rods, and replaceable dirt wiper seals. Each cylinder is tested at 5,000 psi pressure.



Magnetic Strain Gage

Westinghouse Electric Corporation, Box 868, Pittsburgh 30, Pa.

Magnetic strain gage provides an accurate method of directly measuring small distortions in a static member



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Oil Preheater by Mid-West Heat Service, Chicago.

Everything in piping for every design ... from one complete line

Take an Oil Preheater, for example. In this case, Crane equipment controls the flow of steam and heated fuel oil. But regardless of fluids ... or product design ... you get what you need when you specify Crane. One catalog gives you easy access to the world's most comprehensive selection of valves, fittings, pipe and accessories ... in brass, iron, steel and alloy materials.

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CRANE CO., 836 S. Michigan Ave., Chicago 5, Ill.
Branches and Wholesalers Serving All Industrial Areas

FOR LOW PRESSURE APPLICATIONS, *Crane recommends No. 410 100-pound brass gate valves. Upper body—similar in design to high pressure steel valves—combines maximum strength with light weight. Working pressures: 100 pounds saturated steam; 125 pounds water of 200 deg. F.; 125 pounds cold oil or gas. Non-rising stem; screwed ends. Sizes: ¼ to 2 in. Also made with solder-joint ends (No. 1320), in sizes ⅜ to 2 in. Write for folder AD-1725.*

EVERYTHING FROM ...

VALVES • FITTINGS
PIPE • PLUMBING
AND HEATING

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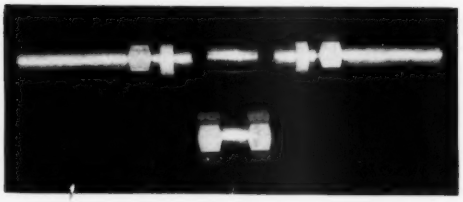
FOR EVERY PIPING SYSTEM

resulting from a tensile or compressive load. Gage can also be used as a warning on metal structures where variations in load approach safe limits of the supporting member. The unit consists of a strain gage inclosed in a water tight case, a pilot bar sensitive to a force as small as 20 lb. which is rigidly mounted to the supporting member, and a controller with indicating dial located wherever desired near the operator. The instrument operates from a single phase 110 v, 60 cycle supply, and frequency variation should not exceed ± 3 percent.

Stainless Steel Union

Steel Products Corp., 52 Vanderbilt Ave., New York 17, N. Y.

Union has a stainless steel body, plastic gaskets and mild steel grip nuts. Assemblies are for use with light or heavy gage tubing for liquid or gas lines, and according to the manufacturers, the plastic gaskets can withstand

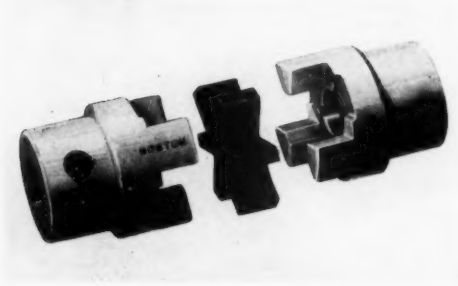


heat up to 400 F and resist the corrosion of acids, organic materials and alkalis. The tubing to be connected requires no threading, and the fitting is recommended for working pressures up to 150 psi. Unions are available in 6 sizes to connect tubes with outside diameters ranging from $\frac{3}{4}$ to $2\frac{1}{4}$ in., and overall lengths of unions in these sizes vary from $2\frac{7}{8}$ to 5 inches.

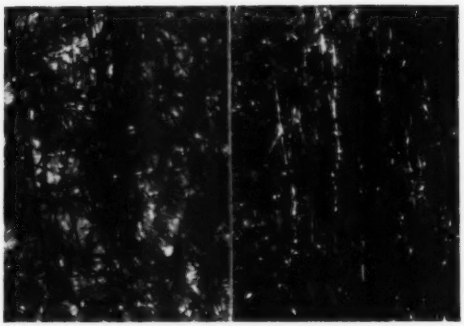
Flexible Couplings

Boston Gear Works, Quincy, Mass.

Oil resistant synthetic rubber insert is flexing element of couplings, type FCR, which are available in 5 sizes rated at from 1.8 to 22.8 hp at 1,800 rpm. Torque ratings range from 65 to 800 lb-in. Provided with standard key-



ways and set screws, couplings will fit shafts from $\frac{3}{8}$ to $1\frac{1}{2}$ in. dia. Keyed members are made of low carbon steel, and over-all length with jaws engaged full depth varies with horsepower rating from about $2\frac{1}{4}$ to $5\frac{1}{2}$ inches.



Lightweight Insulation

Armstrong Cork Co., Building Materials Div., Lancaster, Pa.

Fiberglas XB-PF insulation material was developed for refrigeration and other low temperature equipment. This material is available in two densities: $\frac{1}{2}$ and 1 lb per cu ft. The thermal conductivities of these two different density materials at 75 F are 0.25 and 0.22 Btu per sq ft per hr per in. thickness, respectively. The new finer fibers are revealed in the microphotographs: the one at left is glass fiber material of $3\frac{1}{2}$ lb density and at right is the XB-PF fabric.

Weighing Cells

The Baldwin Locomotive Works, Testing Equipment Dept., Philadelphia 42, Pa.

The weighing cells are designed for measuring tension or compression loads. Elements are available in three sizes that have capacities in compression of 20,000, 40,000 and 60,000 lb. Maximum tension loads of half these capacities may be applied on a removable I-bolt screwed into the inside end of the piston which is made accessible through the closed end of the cell. The cells may be used in any position. Essentially each cell consists of an hydraulic cylinder with a piston having a stroke of less than 0.005 in. under full load. Fluid makes no contact with the piston, but is sealed within the cylinder by a thin metal diaphragm against which the piston rests. Slight movement of the piston produced by load. flexes

16 PUSH-ON TYPE SPEED NUTS PRODUCE 30% Savings

FOR NATIONAL SCIENTIFIC PRODUCTS CO.
Chicago, Illinois

"The 30% cost-saving effected by SPEED NUTS helps keep our prices down and sales up," says Mr. E. L. Hoffman, of National Scientific Products Co.

"Since our junior-size vacuum cleaner is made largely of plastics, it presents a difficult assembly problem. We have found Push-On Type SPEED NUTS the only fast, economical, sure way to fasten plastic parts together. They can be quickly zipped over molded studs and they lock securely by 'biting' into the plastic material. Furthermore, they provide a production cost-savings of 30% over other methods considered!"

If this method of assembly suggests a cost-saving, product-improving idea to you, call on us for immediate service. You may discover many profitable ideas incorporating the SPEED NUT brand of fasteners. The complete line includes more than 4000 shapes and sizes. TINNERMAN PRODUCTS, INC., 2040 Fulton Road, Cleveland 13, Ohio. Offices in principal cities. In Canada: Dominion Fasteners Limited, Hamilton.

Specially-molded clear plastic cleaner reveals 8 of the 16 Push-On type SPEED NUTS in position (red circles) on plastic studs. Simple tool is used to zip on SPEED NUTS.

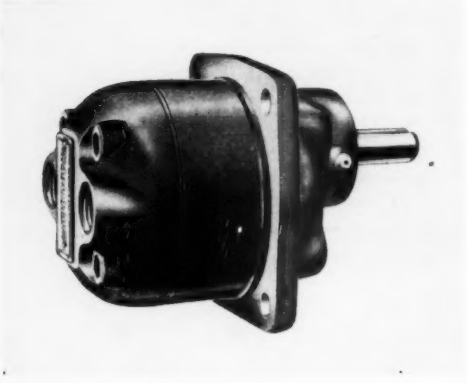
The "Tidy Miss" toy vacuum cleaner has a powerful midget motor which is held in position by SPEED NUTS that won't vibrate loose.

the diaphragm and compresses the hydraulic fluid, thus transmitting pressure to the indicator. Load ranges can be as low as 0 to 1,000 lb. when using a Bourdon tube indicator.

Gear Pump

Hydraulic Equipment Co., 1100 E. 222*nd St.*, *Cleveland* 17, *Ohio*

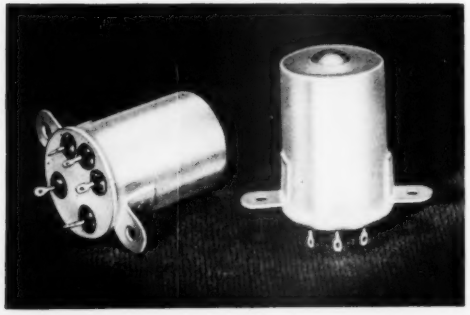
Series 100 gear pump is designed for applications with rigid space restrictions, and incorporates four-bolt mounting with either flange or foot fixtures. Available with or without pulley assembly for either clockwise or counter clockwise rotation, these pumps, depending on gear width, are also made in two capacities, 2.25 gpm and 4.5 gpm. Both models operate at 3,000 rpm and 1,000 psi.

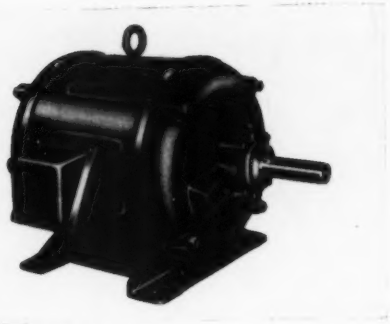


Miniature Relay

Struthers-Dunn Inc., 150 N. 13*th St.*, *Philadelphia* 7, *Pa.*

Type CX3554, hermetically sealed d-c miniature relay was designed for aviation use. Relay will resist shocks up to 50 G; vibration resistance is better than 10 G; and instrument will operate at temperatures ranging from —75 to +200 C. Relay has contacts nominally rated at 2 amp which are capable of withstanding inrushes of 12 amp at 26.5 v, d-c. The coil is rated at 26.5 v, d-c with an operating range of 18-32 v, d-c. The relay is approximately 1¾ in. high.





Large Drip-Proof Motors

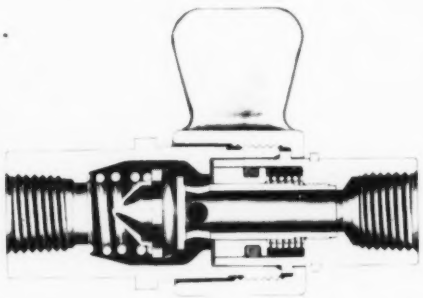
Wagner Electric Corp., 6400 *Plymouth Ave.*, *St. Louis* 14, *Mo.*

Drip-proof design has been adopted for polyphase motors in 254, 284, 324 and 326 frames. Frames on these large motors are formed of rolled steel, shaped accurately to center the stator core and to provide passages between the frame and core for ventilation. An auxiliary fan, larger in diameter than the armature, draws air through opening in the front endplate, forces draft through motor and out of endplate opening in drive end. By rotating endplates, motors can be made equally drip-proof with side-wall or ceiling mountings.

Wing Nut Coupling

Aeroquip Corp., *Jackson, Mich.*

Produced specifically for use with hydraulic fluids, coupling allows fluid-carrying lines to be disconnected without draining the system and without loss of fluid or inclusion of air when reconnected. When disconnected, a poppet valve actuated by a spring and pressure of fluid in line seals male end. A sleeve which slides on the inside diameter of tubular valve in the female connection has a ring packing which also acts as seal. Tightening of wing nut compresses both valve springs and opens



valves, as illustrated above. Coupling is used with air, oil, water and refrigerant gases. With operating temperatures ranging from —40 to +250 F, couplings are available in OD tube sizes from ¼ to 1½ inches.

Time and Cost Saving Features

TYPE "A" ASSEMBLY BIT

ON WHICH CLUTCH HEAD CHALLENGES COMPARISON WITH ANY AND ALL OTHER SCREWS

1. ***What Other Screw*** equals the high visibility of the CLUTCH HEAD recess to check out the slow-down of hesitation . . . even with "green" operators?
2. ***What Other Screw*** frees the line from burred and chewed-up heads with automatic straight driving . . . with Center Pivot entry that prevents driver canting?
3. ***What Other Screw*** has a non-tapered driving engagement (without dangerous "ride-out" as set up by tapered driving) to eliminate the hazard of skid damage? . . . and the need for fatiguing end pressure?
4. ***What Other Screw*** provides a simple Lock-On which unites screw and bit as a unit to hurdle "fumble spots" by permitting one-handed reaching and driving from any angle?
5. ***What Other Driver*** can begin to approach the durability record of the rugged Type "A" Bit . . . 214,000 screws driven non-stop?
6. ***What Other Assembly Bit*** can be *repeatedly* reconditioned on the spot by a 60-second application of the end surface to a grinding wheel . . . for unmatched tool economy.
7. ***What Other Modern Screw*** has a recess basically designed for operation with a common screwdriver . . . for the simplification of field service adjustments?

COMMON SCREWDRIVER

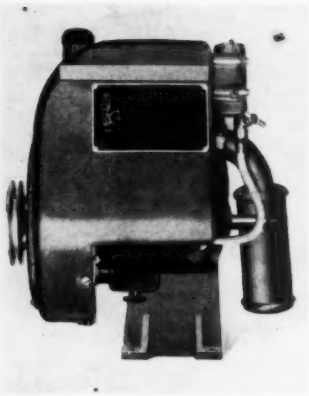
According to users of CLUTCH HEAD *Screws, you may confidently expect these time- and cost-saving features to deliver assembly production increases ranging from 15% to 50%.*

CLUTCH HEAD SCREWS

The New CLUTCH HEAD *Brochure details and illustrates the exclusive advantages of America's Most Modern Screw. Your copy will come to you by mail on request . . . mentioning the types and sizes of screws in which you are interested.*

UNITED SCREW AND BOLT CORPORATION

CLEVELAND 2 CHICAGO 8 NEW YORK 7



Light Gasoline Engine

Reed Prentice Corp., Dept. E-2, Worcester 4, Mass.

Engine weighs 30 lb and is designed for application with portable units such as generators, pumps, compressors, conveyors and the like. Incorporates two-cycle action with air cooling and a diaphragm carburetor which gives steady supply of fuel regardless of the position in which the engine operates. Passage in the crankcase and front cover which allows unburned fuel to return to the carburetor lessens the danger of flooding or overloading the engine. Die cast aluminum parts account for the weight of engine which develops 4 hp at 4,500 rpm, and has a bore and stroke of 2 inches.

Small Speed Reducer

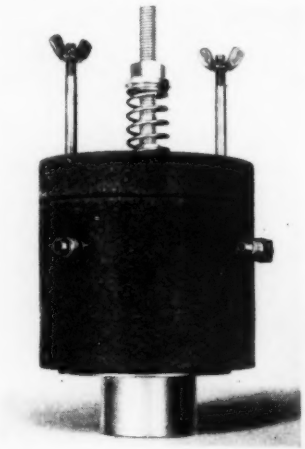
Ohio Gear Co., 1333 E. 179th St., Cleveland 10, Ohio

Speed reducer, designated as BHS, has a right angle drive with the worm output shaft above the input gear shaft. Gear ratios range from 6-1 to 58-1. Input horsepower can vary from $\frac{1}{8}$ to $\frac{3}{8}$, and output torque ranges for 103 to 168 in.-lb, depending on the gear ratio used. Input shaft has $1\frac{5}{8}$ in. extension, and output shaft has $1\frac{13}{16}$ in. extension. Housing is aluminum alloy, the gear is nickel bronze, and the worm is carburized steel. Overall dimensions are $4\frac{3}{4}$ x 3 x $6\frac{1}{4}$ inches.

Low-Range Air Cells

The Baldwin Locomotive Works, Philadelphia 42, Pa.

Air cells have load ranges from 0—1.2 to 0—6 lb, and 0—2, to 0—10 lb in tension and compression. These load-weighing devices are for use on testing machines to give measurement of small loads such as in testing plastics, textiles, paper and other materials. They can also be used independently for such purposes as weighing chemicals or controlling chemical processes.

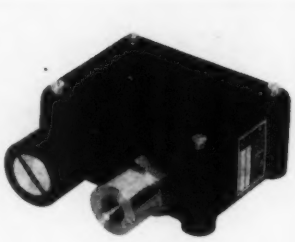


An air jet and baffle within the cell controls the action of a pneumatic force balance system, so that air pressure automatically balances the load. Total movement of the load-sensitive member is less than 0.0005 in. Accuracy of load measurement is $\frac{3}{4}$ percent of rating when Bourdon gage type indicators are used.

Pressure Switch

Saval, Inc., 1915 E. 51 St., Los Angeles 11, Cal.

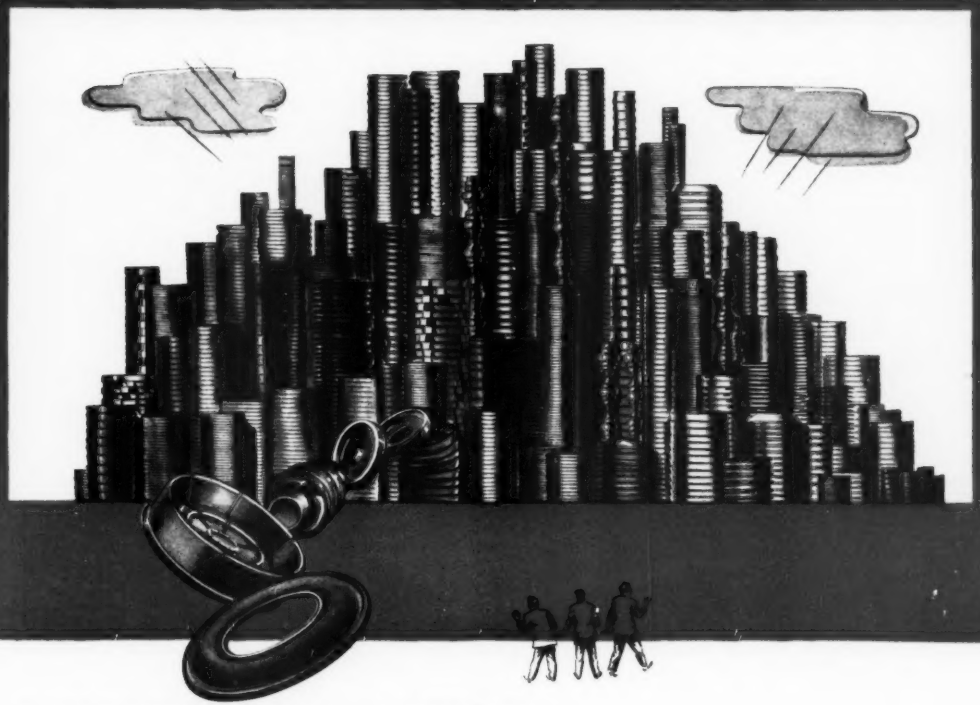
These switches are used for safety control on pumps or other hydraulic machines where pressure control is required or where cycling is controlled by fluid pressure. Actuating pressure setting may be adjusted and locked externally. Differential between cut-in and cut-out pressures is also adjustable on removal of cover plate. Switches are available in six pressure ranges from 50 to 10,000 psi for water, oil or air service. Tapped hydraulic connection is $\frac{1}{4}$ in. pipe thread, and switch housing is drilled for $\frac{1}{2}$ in. conduit connection. Housing is moisture proof and explosion resistant, can be mounted in any position and has four $\frac{1}{4}$ in., 28 NF2 mounting holes.



Air Conditioner

The Black Mfg. Co., 1433 W. Baltimore St., Baltimore 23, Md.

Model N 9500 air conditioner is for use with portable compressors and other air supply equipment. There are no moving parts within the main cylinder which is made of cold impact



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and it's all earmarked

Chances are the Sirvene part you order will be utterly unlike any other. For, while Chicago Rawhide produces literally tons of Sirvene in a year's time, every batch is earmarked for a different pliable part. Each of these parts is designed and developed to do just one special job in a particular mechanism. For every application, Sirvene engineers compound a special formula from pure, oil-resistant elastomers. From it, they mold a custom-engineered part which will fulfill specific requirements in tensile strength, elongation, elasticity or hardness, resilience, and resistance to dryness, moisture, temperature extremes and other deteriorating elements. As a result of laboratory-controlled production methods, Sirvene parts function under unusually severe conditions. That's why engineers across the country depend on Sirvene for their critical pliable parts. Sirvene engineers offer you their unlimited backlog of experience and research. Use it in solving your mechanical elastomer problems.

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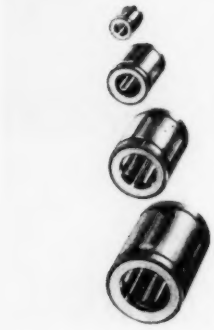
extruded aluminum capable of withstanding pressures up to 1,000 psi. The filtering element, regulator body and cap are brass. Conditioner comes equipped with a regulator with a 100 lb gage showing regulated air pressure, a regulated pressure outlet and a draincock at the bottom of the tube for removal of moisture and oil. Capacity is 14 cu ft per min at 60 lb pressure.

Linear Ball Bushings

Thomson Industries, Inc., Manhasset, N. Y.

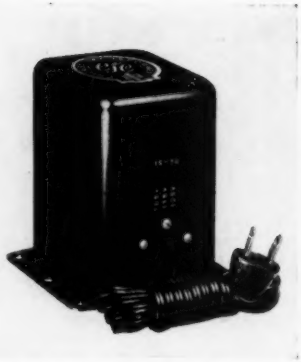
Series B Commercial Grade ball bushings are available in four shaft diameters: $\frac{1}{4}$, $\frac{1}{2}$, $\frac{3}{4}$ and 1 in. They are built to the same basic dimensions and have the same ball recirculation characteristics as the Precision Series A. Lower cost of new Series B is obtained because tolerances are not as close, and because case hardened steel parts are used. Bearings of this design are used on guide rods, reciprocating shafts or for support of any mechanism that is moved or shifted in a straight line.



Isolation Transformers

Essex Wire Corp., Chicago Transformer Div., 3501 Addison St., Chicago 18, Ill.

Isolation transformers with 50, 150, and 250 va capacities are designed for dual purposes. They are suitable either for adjusting high or low line voltages to operate radio, television and other equipment on a normal 115 v, or for experimental work on electronic gear by isolating chassis grounds from line grounds. Besides providing a standard 115 v, the secondaries of these transformers will also supply 125 or 105 v for use in locating faulty set components. Transformers are mounted in compound-filled drawn steel cases, and have a 7 ft coil with a male plug on primary and a female plug on secondary.



Portable Hardness Tester

Ames Precision Machine Works, 131 Lexington St., Waltham 54, Mass.

Instrument, weighing $2\frac{1}{2}$ lb, can measure Rockwell hardness of materials not more than 2 in. thick. Being portable, tester can compute hardness of bars, sheets, cylindrical and odd-shaped parts without the necessity of cutting off samples. Pressure is applied to the penetrators by screw action instead of by weights and levers. As the handwheel is turned to increase pressure, the tester frame is forced open, the lever on the front of the frame lifts causing the indicator hand to move around the dial. Since the movement is minute, it will not permanently change the shape of the frame. Reversible anvils and penetrators, and other accessories are supplied to further increase the number of applications in which this instrument can be utilized.

Wick Oilers

Trico Fuse Mfg. Co., 2948 5th St., Milwaukee 12, Wis.

Variable feed wick oilers are recommended for any equipment having solid bearings oiled from the top. Each oiler is furnished with five different size wicks. The rate of feed is adjustable to the amount desired by inserting heavier wicks into the retainer to reduce the flow, or light wicks when faster feed is desired. When extremely heavy oil is used, the wicks can be eliminated entirely. Wicks can be removed, cleaned or changed by unscrewing the retainer at the base of the assembly. The plastic bottle allows visibility of the oil reserve, and the oilers are available in four types having 1, 2, 4, and 8 oz capacities.

Case-Hardening Paste

Denfis Chemical Laboratories Inc., 172 Pacific St., Brooklyn 2, N. Y.

A paste, called Carburit, does case-hardening jobs without special equipment, and is suitable for selective hardening. For example, the section to be hardened is covered with a paste

Announcing A New LOW COST Ball Bearing for Your

LINEAR MOTIONS

THE COMMERCIAL GRADE SERIES B

BALL BUSHING

Sliding linear motions are nearly always troublesome. Thousands of progressive engineers have solved this problem by application of the Precision Series A Ball Bushing.

The low-cost Commercial Grade Series B bearing is now added to the Ball Bushing line and offered to original equipment manufacturers. This ball bearing has been developed for support of linear motions in competitively priced, volume produced products where super precision is not essential. Alert designers can now make tremendous improvements in their products by using Ball Bushings on guide rods, reciprocating shafts, push-pull actions, or for support of any mechanism that is moved or shifted in a straight line.

Competition is returning. Up-to-date engineering can be *important to you!*

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- ELIMINATE BINDING AND CHATTER
- SOLVES SLIDING LUBRICATION PROBLEMS
- LASTING ALIGNMENT
- LOW MAINTENANCE
- LONG LIFE

NOW AVAILABLE for ¼", ½", ¾" and 1" shaft diameters. Additional sizes to follow. Write for new literature covering both the Series A and Series B Ball Bushings and the name of our representative in your city. No obligation.

THOMSON INDUSTRIES, INC.

Dept. F *MANHASSET, NEW YORK*

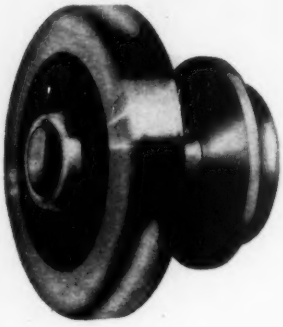
PROGRESSIVE MANUFACTURERS USE BALL BUSHINGS—A MAJOR IMPROVEMENT AT A MINOR COST

layer and the work is heated to 1,700 F. The paste imparts carbon to the surface covered. A case 0.010 in. thick will form in 5 to 7 min, and 25-30 min are required for a 0.040 in. case. After heating with Carburit in place, the work is cooled and reheated to 1,500 F. Then the paste, which dries brittle, is knocked off and the part is quenched. Any method of heating can be used, and according to the maker, the hardness produced compares favorably with that created by all other known methods.

Centrifugal Clutch

W.S.K. Inc., 405 Donovan Bldg., Detroit 1, Mich.

Automatic V-belt transmission, known as Flex-A-Matic, is operated by means of centrifugal force. The mechanism is normally set to engage at 1,400 rpm

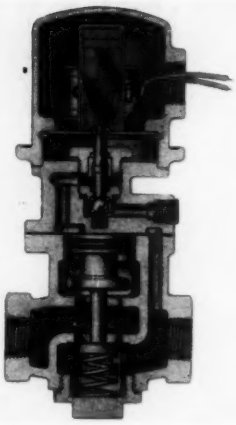


under no load, 1,700 rpm under full load, but the clutch can be adjusted during manufacture to pick up load at different speeds. If the proper belt length is installed, the engaging mechanism will automatically compensate for wear and stretch of the belt. The clutch functions as a variable pitch pulley which engages at a smaller diameter than that at which it operates. Assemblies have bores from ½ to ¾ in., and accommodate ½ and 21/32 belt sizes.

Air Control Valves

Ross Operating Valve Co., 120 E. Golden Gate Ave., Detroit 3, Mich.

Built to control air power on machine tools and similar applications, inline valves are available in both 3-way and straightway models. Sizes ¼ and



¾ in. are of the pilot type with a solenoid releasing the air power which operates the valve. Models can be furnished with inlet ports either normally open or normally closed. Valves handle vacuum as well as air, liquid or gas pressures up to 125 psi; special models can be supplied for use up to 450 psi. Current consumption is 0.2 amp holding and 1.2 amp inrush with 110 v, 60 cycles current.

Electro-Mechanical Counters

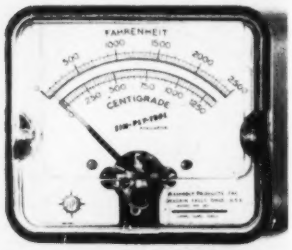
Engineering Research Associates, Inc., 1902 W. Minnehaha Ave., St. Paul 4, Minn.

Electro-mechanical counting units can be stacked to six digits, and will provide carryover at an operating speed of 1,200 counts per min. When a counter capacity is reached and the reading becomes zero, an alarm contact stops the counter and holds alarm circuit closed. After a count, the subtotaling circuit can be used to transmit the count to a printing device. Small frontal area permits banking many counters on a small panel. Cell dimensions are about 1⅛ x 1⅞ x 4¾ in. Each cell requires 11 w power and operates on 115 v direct current.

Indicating Pyrometer

Assembly Products, Inc., Main & Bell St., Chagrin Falls, Ohio

Instrument is offered in several ranges for heat up to 2,500 F. A resistance spool, connected in the thermocouple circuit, is brought out to an extra



terminal on the back of the meter. With this in the circuit, thermocouples with uncalibrated leads up to 15 ft long are used. Magnets with sintered iron poles provide the extra flux for high torque movement. The moving elements ride on pivots in sapphire jewels and have phosphor bronze hairsprings. Instrument can be used in any position, and is fully compensated for ambient temperature.

Corrosion Resistant Coatings

Munray Products, Inc., 12400 Crossburn Ave., Cleveland 11, Ohio

Corrosion resistant plastic coating, known as Cyclon, was developed for the finishing of machinery and processing equipment. Cyclon air dries to a flexible glossy coating without the necessity of priming the surface being coated. Coatings are unaffected by all alkalies and their salts, and by most mineral acids. These films are inert to alcohols, oxidants, food and fruit acids, oils and other corrosive reagents. Films of 0.002 in. thickness have a moisture vapor transmission rate of less than 2.0 g per 100 sq in. of area for 24 hours at 100 percent relative humidity. Coatings will maintain their flexibility at temperatures up to 180 Fahrenheit.

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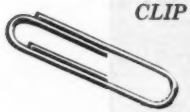

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Silicone News

DC SILICONES

DC 44 Silicone Grease Ends Bearing Failure in Textile Plant

Bearing failure may burn out your motors, stop your entire production line or ruin a mill run. That's why it's front page industrial news when the Plant Manager of a large textile plant reports that he has not had a single bearing failure since he started to use Dow Corning Silicone Oils and Greases over 30 months ago.

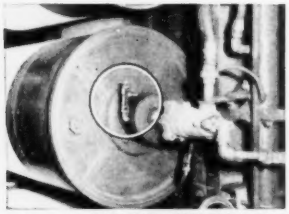

PHOTO COURTESY AMERICAN FINISHING COMPANY

DC 44 Silicone Grease in ball bearings on drying cans, operating at 400 r.p.m. around saturated steam journals, has 45 times the life of the organic grease previously used.

Typical of the lubrication problems that plague plant engineers in textile plants is the maintenance of "steam-heated" bearings. It used to be necessary to lubricate bearings on drying cans and the main cylinder bearings of Sanforizing machines once every 8-hour shift. Since American Finishing started to use DC 44, the re-lubrication schedule has been cut to once every 30 to 45 shifts. The lubrication of Slashers on textile mills presented a similar problem that has been solved by using DC 44.

On tenter frame chains and races that travel through ovens at 400° F., petroleum oils carbonized so rapidly that the chains had to be cleaned periodically. That costly operation and the need for continuous lubrication have been eliminated by a weekly application of DC 710R Silicone Fluid.

American Finishing, like many other skillfully engineered companies, has found that Dow Corning Silicone lubricants more than pay for themselves in reduced maintenance costs. Increased production due to the virtual elimination of bearing failure is another one of the many bonuses Dow Corning Silicones pay to modern industry. For the most recent data on DC Silicone Greases phone our nearest branch office or write for data sheet No. D5H.

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FIRST IN SILICONES

OUR READERS SAY

Mechanical Engineers And Aerodynamics

To the Editor:

Recent engine developments, especially in the field of gas turbines, have brought a large section of mechanical engineers into close contact with the field of fluid mechanics, with which twenty years ago even the mechanical engineer working on steam turbines had but a nodding acquaintance. This is so much the case that the modern power plant field is being invaded by aerodynamicists. The important fact, and the motive of this letter, is that to progress in the turbo field beyond that line reached by the mechanical engineer of yesterday, it is necessary to have a working knowledge of fluid mechanics many times more extensive than the standard one-semester course that makes up the "official" training for non-aeronautical engineers.

If the engineer working on modern engine development wants to apply whatever results of aerodynamic research are useful to his end, the following question is unavoidable:

"What is the minimum knowledge of fluid mechanics that will enable one to do a discriminating job?"

To illustrate the difficulty of a practicable—and therefore valid—answer, let the knowledge of fluid mechanics necessary for an aeronautical engineer to participate in the preliminary design of a simple airplane be compared with that necessary for a mechanical engineer to take part in the design of, say, an axial flow turbo unit:

For the Aeronautical Engineer:

1. Two dimensional airfoil theory.
2. The mechanics of performance calculations.
3. The elements of airplane stability.
4. A general idea of friction drag.
5. Induced effects.
6. Parts interferences.

The counterpart for the Mechanical Engineer is:

1. Same, but less thorough.
2. Efficiency calculation.
3. Range of operation.
4. Same, but more complete.
5. Slip angle effects.
6. Tip clearance and hub effects.

Assume now that the aeronautical engineer is supposed to take a leading part in the design of a new airplane

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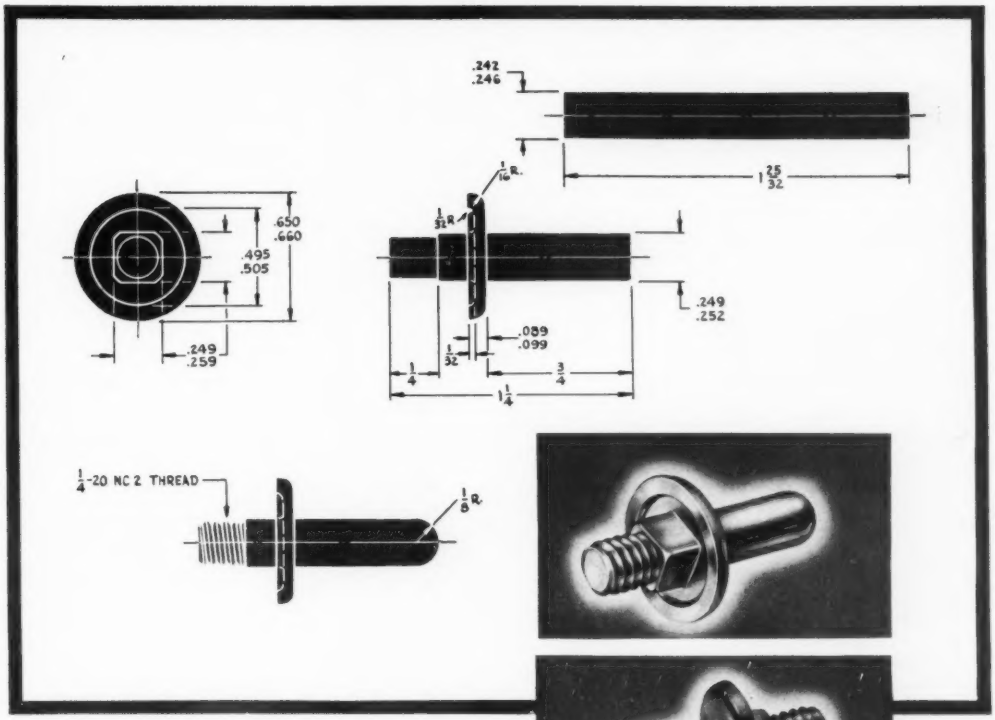

illustration enlarged to show detail

Designers' dreams come true when cold heading is their process

There is a latitude in the cold heading process that gives designers freedom to usually get exactly the shape and dimensions of a small component part or fastener that meets their needs.

Surprisingly enough, even the most unusual parts are produced by cold heading—faster, more accurately, and with a greater saving of metal than in any other possible way. The part is strengthened through cold forging of the metal. Close tolerances are held. Fine finishes are the rule. Tool expense is a minor item. Actually, many shapes can be produced only by cold heading.

Consider this unusual piece

Here is a bracket for a refrigerator shelf, made of brass, chrome plated, or aluminum with anodized finish. Please examine the illustration closely. Note the square shoulder. Note the cup for a neoprene washer.

This part is made exactly as the designer specified it. It speeds assembly on the production line. Its design and finish have the enthusiastic OK of sales department inspectors.

Let's talk about your problems

Problems like this are not unusual here at Scovill. May we work with you when parts you want are still in the design stage?

Send for "A Guide to the Profitable Use of Cold Heading" for detailed description of the advantages and limitations of this process.

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and that, analogically, the mechanical engineer has also a leading role in the design of a new turbo unit. Again, to any requirement of aerodynamic knowledge for the first, one may find a corresponding "must" for the second in the same field. The following "correlation" table is suggested as an addition to that above to illustrate the point.

Aeronautical Engineer:
1. Three dimensional theory of airfoil.
2. Boundary layers.
3. Propeller theory.
4. Compressible fluids.
5. Turbulence.

For the Mechanical Engineer:
1. Same.
2. Same, but more complete understanding of the friction phenomenon.
3. Three dimensional arrangements of blades.
4. Same.
5. Multistage effects.

Following the above reasoning, one could answer the proposed question as follows:

"The mechanical engineer engaged in certain types of engine development should be critically acquainted with:
1. Airfoil and cascade theory.
2. Vortex theory.
3. Boundary layer phenomenon.
4. Compressibility.
5. The general nature of the mechanism of energy input and output on a fluid mass."

To provide the mechanical engineer with such a knowledge in a relatively short time is one of the many demands now placed before our technological schools. Such a training would allow the mechanical engineer to maintain the lead and to work successfully with the aerodynamicist who has come into his field to stay. —F. G. GRAVALOS
Associate Professor of Aeronautical Engineering

About Titanium

To the Editor:

Recently I have heard a great deal of talk about the increasing use of titanium. I understand that this metal is competing with better known metals such as steel, aluminum and magnesium. Just how true is this, and how much use can this new metal be to designers?—ROBERT F. MEURLIN
Ottawa, Canada

Ed.—At the beginning, we should like to inform you that titanium is far from being a new metal. It was discovered in 1791 by W. Gregor of Cornwall, England. Since the 18th century a great many of deposits of titanium have been discovered, so that today it is considered to be the 4th

most plentiful of the elements that might be used for construction, and the 7th most common metal. The principal ores from which titanium can be extracted, rutile and ilmenite, occur in huge quantities in the United States and Canada.

The DuPont Company now has a pilot plant with 100 lb daily capacity for the production of titanium in sponge form at about five dollars per pound. The figure indicates that at the moment titanium is not a strong competitor with the better known metals, but in mass production the price should be greatly reduced.

It use in aircraft and other forms of land and sea transportation seems assured because of its high weight-strength ratio and its resistance to atmospheric and salt water corrosion. Moving parts in textile and other machinery could be made of titanium, and the chemical industry will probably find considerable use for this metal.

Some attempts have been made to coat various metals with titanium, but unfortunately the junction layers beteween titanium and such metals as iron, nickel, cobalt and copper are too brittle for satisfactory performance. As yet, very little is known about titanium-base alloys, but it is believed that alloys of titanium will be widely used by design engineers.

Aluminum vs. Steel

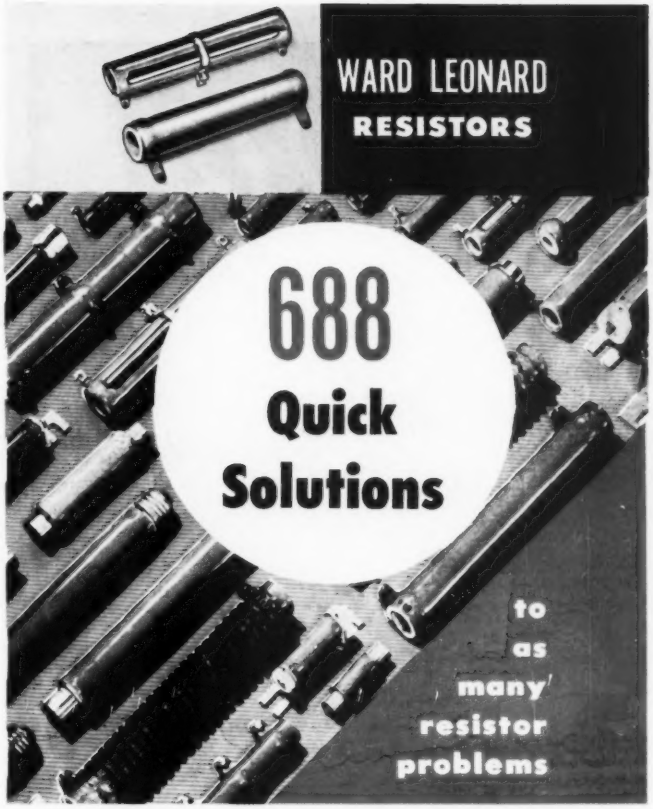
To the Editor:

In your October issue you ran a design story about a change over from aluminum casting to drawn steel fabrication for diesel cylinder covers.

While we look with repugnance at any change from aluminum to steel, we were most concerned with your categorical statement that "Former aluminum castings broke when dropped". We have done considerable work with aluminum castings and have proved them to be reasonably non-breakable. Even if they are distorted by careless handling, they can be made ductile enough to be realigned.

—D. F. HACKSTAFF
Oberdorfer Foundries, Inc.

Ed.—The statement that you quoted in your letter was originated by the persons involved in this particular product design. Of course, in the case of aluminum die casting, the choice of the alloying element has a marked influence on the brittleness of the final casting. A large amount of silicon will decrease the ductility to such an extent that even the strengthening ribs in the design will not prevent immoderate breakage. As you imply, if breakage occurred when these



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Washington Steel Corporation announces a contest with $500.00 in prizes for suggestions for new uses or applications of MicroRold stainless steel sheet and strip in gauges of .015 or thinner. Entries will be judged on the basis of economic practicability and originality by a board of three impartial judges selected by the corporation; the decisions of the board will be final. There is no limit on the number of suggestions that each entrant may submit.

By submitting an entry each contestant grants to Washington Steel Corporation the non-exclusive right to promote the manufacture and sale of any article or idea contained in the entry. All entries must be submitted on your company letterhead.

The contest closes at midnight, June 30, 1949, and all entries must be postmarked on or before that time. Winners will be notified by mail on or before July 31, 1949. Duplicate prizes will be awarded in case of ties.

Employees of Washington Steel Corporation and its advertising agency and members of their families are ineligible. The contest is subject to all applicable federal, state and local laws.

Mail entries to:
Contest Headquarters,
Washington Steel Corporation,
Washington, Pennsylvania.

WASHINGTON STEEL CORPORATION
122 Woodland Avenue **Washington, Pennsylvania**

aluminum castings were mishandled, the solution to the problem might have been a redesign rather than a switch to another fabrication material.

Mysterious Metals

To the Editor:

The rare metal gallium which you mentioned in the March "Highlights" section interested me greatly. Could you tell me more about this metal and who manufactures it?

—DONALD D. BOUDREAU,
Syracuse, N. Y.

Ed.—Traces of gallium are found in a variety of ores and minerals, but it is being derived by the Aluminum Company of America from bauxite. It is estimated that a ton of bauxite contains one ounce of gallium.

Gallium shows a strong tendency to undercool; and although its melting point is 86 F, it can be held at about 40 F without solidification. A natural protective oxide forms on this metal's surface so that, even at 1,000 F, a globule of gallium will remain bright and shiny. Like water, but unlike most elements, gallium expands when solidifying. This combination of properties should make possible a variety of unusual applications for this rare metal which is now being marketed by the ounce.

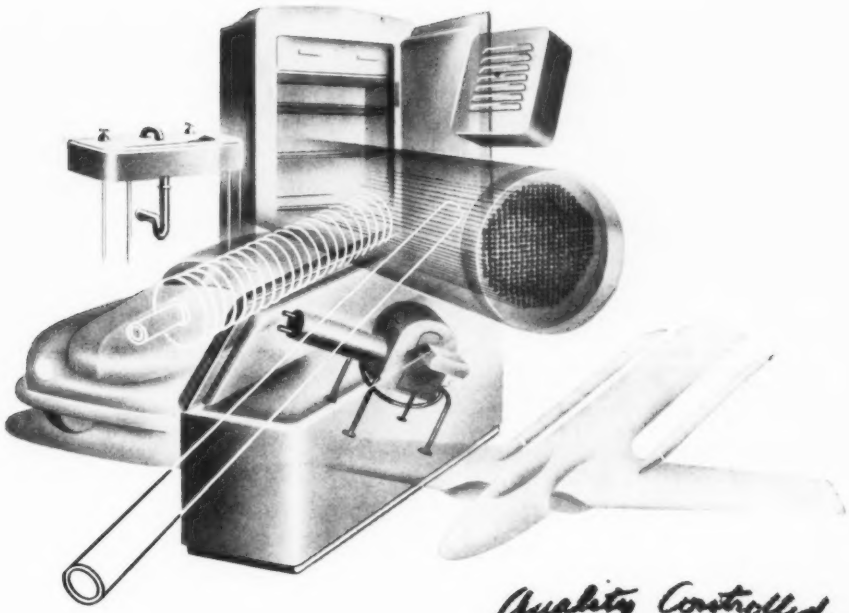
To the Editor:

I don't want to pose as a walking encyclopedia; but there is something you ought to know. The March "Highlights" section carried a note that "Scientific and commercial use of rhenium is now a reality." This statement is short and concise, but far from being a Winchell "Flash". In 1929 rhenium was available in kilogram quantities as marketed by Vereingte Chemische Fabrik, Leopoldshall, Germany; a subsidiary of the potash producers.

I realize recently there has been a sizable amount of rare metal research which, I suppose, is partly directed to serving the needs of atomic development. The cloud of mystery covering the work of nuclear physicists has also cast a veil over our knowledge of the rare metals. If you could unearth some more information about rhenium, I should be more than willing to acknowledge you as my source of data.

—JAMES MEDFORD,
Quebec, P. Q., Canada.

Ed.—As the reader implied, much of the available information about rhenium is quite dated. The metal was first detected with the help of the Roentgen spectrum. Its specific weight is 21.1, atomic weight 186.3, and its



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What's more, it's assembled to the chair in a jiffy. You simply slide a headed insert into a slot, flex the rubber around the curve, and run up two screws from underneath.

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melting point somewhere from 5,790 to 6,160 F. If the higher melting point is correct, rhenium would rank with tungsten, with which it also shares other characteristics.

A pioneering article which appeared in Metallwirtschaft Magazine (26, 12, 1930) dealt with tungsten—rhenium alloys. The writers, Becker and Moers, were very much impressed by the fact that, as more rhenium was added in the alloy, the melting point was reduced until it reached its lowest point (3,100 K) when equal proportions of tungsten and rhenium were used. As more rhenium was added the melting point advanced again.

Because of the rarity of this metal and the difficulty connected with its extraction, rhenium's properties have not been fully examined. At the Univ. of Tennessee, water is added to a molybdenum sulfide flue gas and the solution is filtered and treated with potassium chloride to obtain a crude rhenium salt. The white, powdery salt is purified, and converted into heavy, black rhenium metal which might find use in the electric lamp, radio and television industries. We would not even like to hazard a guess as to this element's use as a coolant in atomic piles.

LeTourneau Gear System

To the Editor:

For the last three years the adoption of our own gear system has proved so satisfactory, that I thought you might be interested in some of its salient points.

The old 14½ deg pressure angle was discarded by automotive engineers some years ago in favor of the 20 deg angle, but we have found that by using a 25 deg pressure angle, a tooth could be made 80 percent stronger while bearing loads only increased 4 percent.

Then, instead of using the Fellows system we adapted a snub tooth making addendum and dedendum 0.8 and 1.1 respectively, divided by the diametral pitch.

A 30 deg helix angle has the advantage of getting tooth lap on a narrow gear, but the actual tooth pressure at right angles to the tooth is 15 percent greater than the load in the plane of rotation. With a 20 deg helix angle the actual tooth pressure is 8½ percent less than with the 30 deg angle, and yet it is steep enough to give a good lap and a smooth operating gear. The decrease in helix angle also gives a thicker tooth for the same diametral pitch in the plane of rotation, thus adding about 17½ percent to the strength of the tooth.

In designing gears that will run

Two views of a steel mill table roll body cast of Meehanite Metal by the Shenango-Penn *Centrifugal* process, assuring exceptional life. Note exterior and interior machining. Shenango-Penn facilities include modern equipment for economical machine work of virtually every type and to any stage to best meet your particular needs.

Maybe you can profit by steel mill experience

THIS conveyor roll is going to save a steel mill some money. Because it is a Shenango-Penn *centrifugal* casting of Meehanite Metal, it will hold up longer than an ordinary roll . . . won't need replacement nearly so soon! That's good economy, don't you think?

Fundamentally that's why Shenango-Penn is producing symmetrical, annular and tubular parts, large and small, ferrous and non-ferrous, for many services in many industries. The Shenango-Penn *centrifugal* casting process results in more uniform, pressure-dense parts with finer grain, greater strength, superior wear resistance and freedom from sand inclusions and blow holes. Metal for metal, dollar for dollar, they do a better job. It pays!

As always, we welcome the chance to give you further evidence, specific facts, as to why it will pay *you* to specify Shenango-Penn. Send for a free bulletin on our ferrous or non-ferrous made-to-order centrifugal castings or on our *centrifugally cast* bronze bushing stock in standard sizes.

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Use the Iridite treatments, too, as a final finish for extreme corrosion resistance, or as a bright finish that keeps zinc or cadmium plated parts shining, clear of stains.

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with small pinions, we favor the pinion which is naturally the weakest member. To do this, move the pitch line towards the base of the pinion tooth, and farther out from the base of the gear tooth. This is accomplished by subtracting from the OD of the gear and adding a like amount to the pinion. Leave the centers standard, and simply run the cutters in full depth. Any amount can be so subtracted, provided the pitch line is not run outside the gear. Unless there are some special requirements, make the OD of the gear one addendum larger than its pitch, and the OD of pinion three addenda larger than its pitch. We call this the 3-1 Addenda System. By using this ratio, a seven tooth pinion will operate satisfactorily, and tooth strength will be more than doubled over other methods.

When there is a pinion of nine or less meshing teeth, shave the tooth face to a slightly crowned form. In this shaving process, rather than use a proturberance hob, use a cutter with a 24½ deg. pressure angle. Normally, crowning only the pinion will give satisfactory results.

These are the essentials of the LeTourneau System, but it should also be stated that even greater strength can be added to teeth by shot blasting. This puts the surface metal under compression and lessens the chances of cracking. —LeTourneau

X-Ray Testing

To the Editor:

I am very interested in the new X-ray instruments which are becoming more and more a part of research engineering. The other day at a business luncheon I overhead talk of an X-ray thickness gage which has recently been designed, and wondered if you know of this instrument.

—Joseph Holland
Chestnut Hill, Pa.

Ed.—The Westinghouse Electric Corp. recently developed such an instrument. According to the manufacturer, no contact is made with the material being tested, and thickness variations as low as 0.000005 in. are indicated. Essentially, the gage consists of two X-ray sources of equal intensity which transmit the rays through a sample and through the material under test to a pick-up. If the sample and the test piece are of equal thickness, they will absorb the same amount of radiation, and the X-rays passing through to the pick-up will be equal. If the material tested is thicker or thinner than the sample, unequal radiation will be transmitted, and this difference can be converted into the thickness differential.

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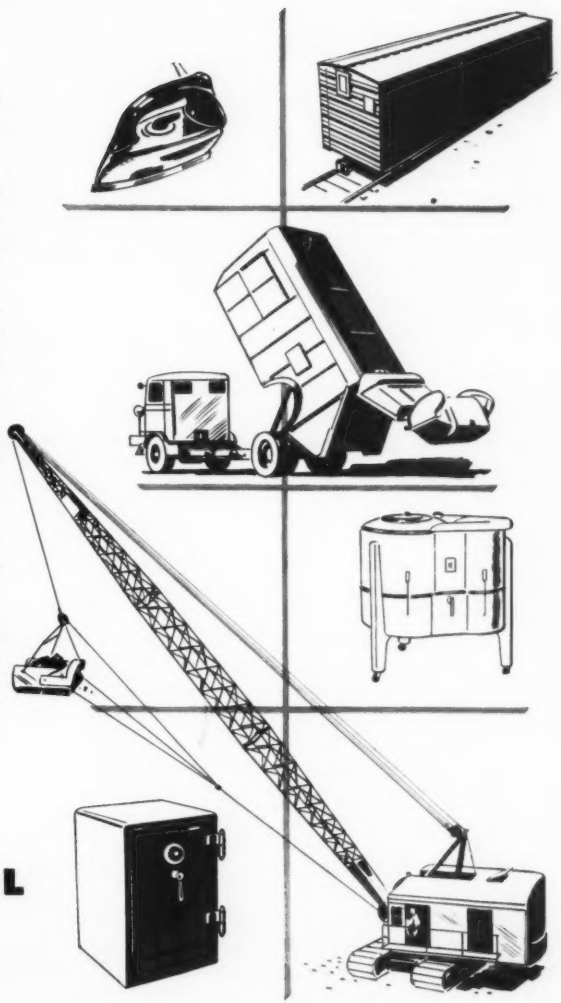
Further information on this steel, its properties, and its many industrial applications may be found in Mayari R Catalog 209. Write or phone our nearest office for a copy.



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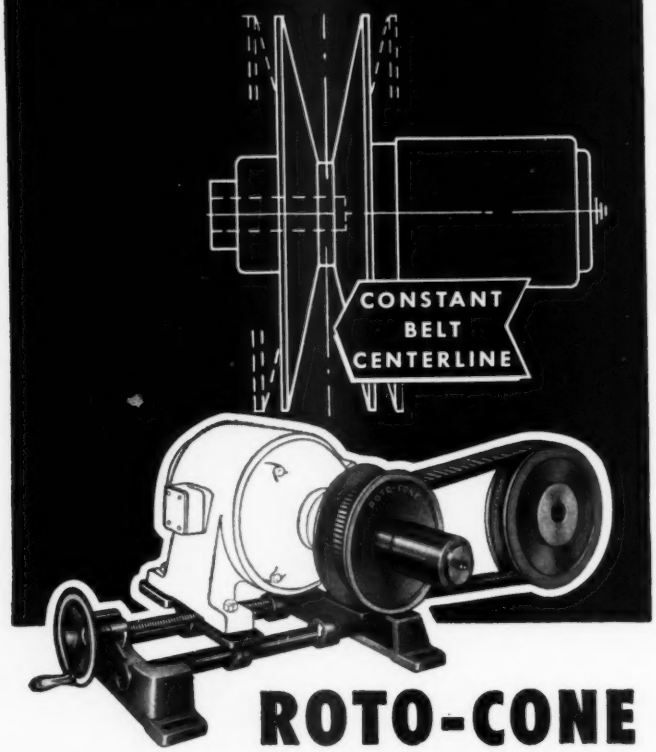

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NEW BOOKS

A. S. T. M. Standards, Parts I-B & II

1948 *Supplements published by the American Society for Testing Materials,* 1916 *Race Street, Philadelphia* 3, *Pa. For non-members* $4; *and for members* $3 *per copy.*

This 1948 Supplement to Part I-B on Nonferrous Metals, of the 1946 Book of A.S.T.M. Standards, contains the revised standards, and the new and revised tentatives that have been accepted since the appearance of the 1947 Supplement. The 14 Standards are replacements of existing standards; similarly, 35 of the 46 Tentatives are replacements, while the remaining eleven are published for the first time. Eleven Tentatives adopted as Standard in 1948 without revision are listed in the Contents, but are not published in this Supplement.

Part I-B covers the following subjects: Wire, rods and stranded conductors for electrical purposes (aluminum, copper and copper-covered steel); copper and copper-base alloys; aluminum and aluminum-base alloys; zinc and zinc-base alloys; magnesium and magnesium-base alloys; lead- and tin-base alloys; die-castings; electrical heating, resistance and related alloys; and metal powders and products.

Part II on Nonmetallic Materials-Constructional, contains 34 Standards of which 13 are newly adopted and 21 are replacements of existing Standards; similarly, 22 of the 43 Tentatives are replacements, while the remaining 21 are published for the first time. The subjects of particular interest are those dealing with thermal insulating materials; wood; paint, varnish, and related products; and thermometers.

Designing for Alcoa Die Castings

PUBLISHED BY THE ALUMINUM COMPANY OF AMERICA, *Pittsburgh, Pa.* 188 *pages,* 5½ x 8¼ *in.*

This book is particularly timely because of the growing importance of aluminum and magnesium as die casting materials. It contains data on the various aluminum and magnesium alloy specifications commonly used for die castings, on the factors governing their selection, and on the mechanical and physical properties of each. It covers the design of die castings made of these materials and how the design

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affects the mold cost; and it includes chapters on machining, finishing, and inspecting and testing die castings. In addition, there are introductory chapters on where to use light-metal die casting, the die casting machine, and die casting dies.

The theme of the chapter on alloys is proper selection to get the required properties in the die cast part at minimum cost. In the chapter on design, the emphasis is not on how to solve the unusual situation but rather on how to design the castings so that (1) the first cost of the die is kept low; and (2) the metal can be gotten into and the part can be gotten out of the die cavity in the least possible time.

There are two outstanding features about this book. As might be expected of a text sponsored by Alcoa, it is unusually complete and exceptionally thorough. Consider for example, this paragraph from the chapter on alloys.

"Alloy 13 contains 12 percent silicon, the eutectic composition which results in the lowest melting point. It has high fluidity in the molten state and is the most readily castable alloy. It is, however, subject to abrupt solidification when approaching the setting point, and is less suitable for cold chamber die casting machines than Alloy 360, with 9½ percent silicon and 0.5 percent magnesium. This alloy was developed to provide an easily cast, high-silicon alloy for cold chamber machines, with tensile and yield strengths equivalent to those of Alloy 13. Alloy A360 is the same as Alloy 360 except that the iron content is held to narrow limits and, in addition, it has higher ductility than Alloy 360. See pages 48 and 49 for tabulated mechanical properties of these alloys."

The second outstanding feature are the illustrations, most of which are shaded projection drawings specially prepared to illustrate the points discussed in the text.

The book should be valuable as a guide to the designer toward the more effective and economical use of die castings.

Modern Introductory Physics

IRA M. FREEMAN, *Associate Professor of Physics, Rutgers University, First Edition.* 491 *pages,* 9 x 6 *in. Published by McGraw-Hill Book Co., Inc.,* 330 *West* 42*nd St., New York* 18, *N. Y.* $4.50.

Written from a new and progressive viewpoint, this text for beginning courses taken by science students treats the subject matter of college physics in a seletive rather than an encyclopedic manner. Thus an effort has been made to include only those portions of classical mechanics, electricity and optics

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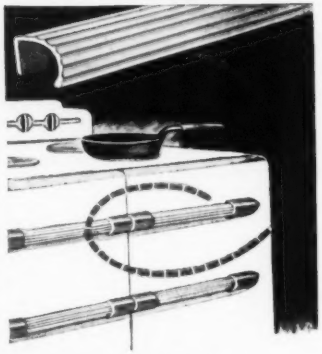

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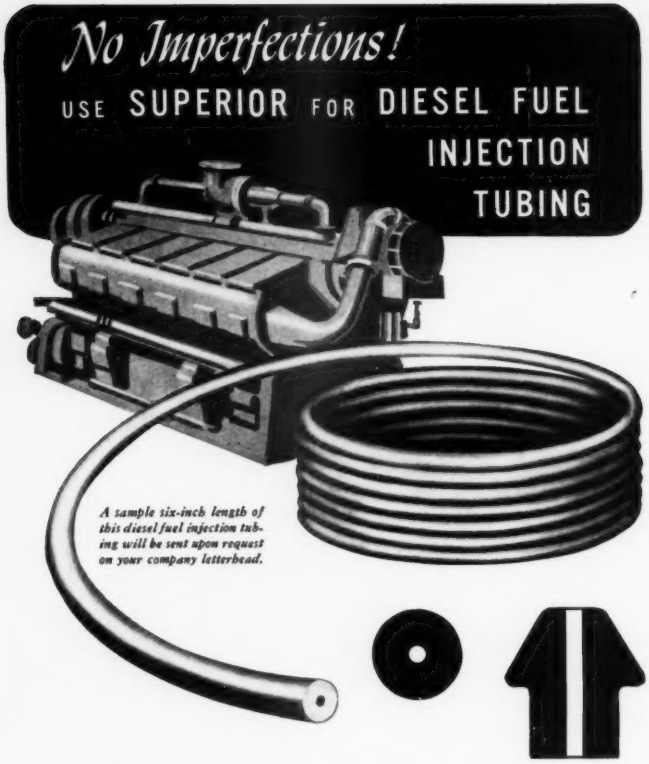
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that are held to be of fundamental importance and which are a prerequisite to an understanding of modern developments. Limitation of subject matter allows reasonable time for exploring the wider implications of the subject and for examining its method of attacking problems.

Appended to each chapter is a list of several books, journal articles, and pamphlets for additional reading. This reference material was chosen because it appeared to complement the text matter and offer further insight into some of the topics treated. Some of the references are to original papers, many more are to interpretative accounts written in the light of modern knowledge, and very few are to other elementary textbooks.

Advanced Mathematics for Engineers

H. W. REDDICK *and* F. H. MILLER. *Second edition.* 508 *pages,* 5½ x 8½ *in. Published by John Wiley & Sons, Inc., 440 Fourth Ave., New York* 16, *N. Y. Price* $5.00.

The authors, professors of mathematics at New York University and The Cooper Union School of Engineering, have evolved this textbook from courses given to advanced undergraduate engineering students. This new edition retains the features of the original volume, with few exceptions. These occur mainly in the chapters on elliptic integrals and Fourier series.

Designed to show some of the roles played by advanced mathematics in engineering technology, the book has no well-defined unifying theme. Rather, it is made up of a number of more or less distinct topics. These include ordinary differential equations, hyperbolic functions, elliptic integrals, infinite series, Fourier series, Gamma and Bessel functions, partial derivatives and partial differential equations, vector analysis, probability, functions of a complex variable, and operational calculus.

Fluid Dynamics

VICTOR L. STREETER, *Research Professor in Mechanics, Director of Fundamental Fluids Research, Illinois Institute of Technology.* 263 *pages,* 9 *x* 6 *in. Published by McGraw-Hill Book Company, Inc., 330 West 42nd St., New York* 18, *N. Y.* $5.

This new text is designed for use as a second course in fluid mechanics for graduate students. It introduces advanced students to the classical theory of fluid flow and covers the ideal fluid theory for both two- and three-dimen-

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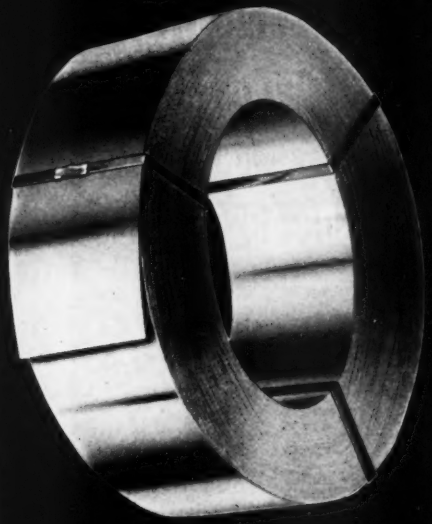

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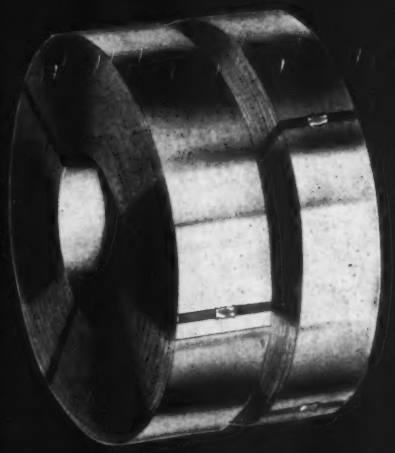

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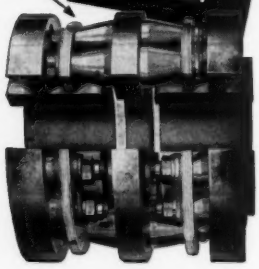

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sional flow, as well as the theory for viscous flow. Emphasis is placed upon the solution of problems that aid the student in his understanding of theoretical material.

Mathematics beyond calculus has been introduced and developed in the text. There are a number of worked-out examples and several new flow patterns.

The book first formulates the basic ideal fluid theory, followed by examples of three-dimensional flow. Then, the necessary concepts in complex variables are introduced, so that all two-dimensional flow cases can be approached from the viewpoint of conformal mapping. Free streamlines are introduced with several examples of their use. Vortex theory is then developed, with two- and three- dimensional examples. The Navier-Stokes equations are derived and applied to several flow problems, including the laminar boundary layer.

200 Designs For Lower Cost
SEE JUNE ISSUE

The Dynamics of Automatic Controls

Translated and edited by H. L. MASON, *Research Professor of Mechanical Engineering, Iowa State College.* 276 *pages,* 6 x 9 *in. Published by the American Society of Mechanical Engineers,* 29 *W.* 39*th St., New York* 18, *N.Y.* $7.50.

The purpose of this book is to present the dynamic properties which all controllers possess in common, freed from every constructional and technological detail. Considerable space is devoted to the underlying mathematical and technical principles.

The examples treated are always carried forward to the ultimate result. Control theory has been definitely advanced by the concept of "effectiveness of control", the introduction of which permits a comprehensive grasp of the stable balancing-out processes, even for problems of higher order. This concept of effectiveness—whether the simple mathematical definition or a derived one is used—together with the author's characterization of technical plants, appears to be very suitable for the theoretical mastery of heretofore unsolved control problems.

The treatment of non-linearities, especially friction and play, is also explored. The book touches upon the on-off regulator which is of great practical significance, particularly in regard to the question of its field of

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application. The theory of the excursion-dependent periodic controller is presented very fully since this important branch of controller technology has not previously been treated and because the computational processes which are required differ markedly from the usual methods.

All examples were chosen with the aim of emphasizing the application of basic principles. The book is based on a monograph discovered in 1945 in Germany by a U. S. Department of Commerce group.

Designing For Economical Production

SEE THE JUNE ISSUE

Machine Design Drawing Room Problems

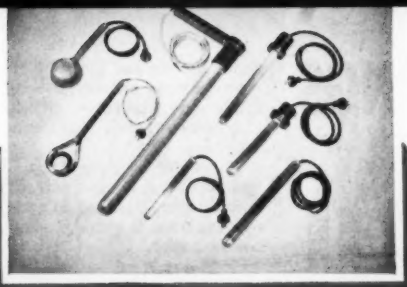
C. D. ALBERT, *Professor of Machine Design, Emeritus, Cornell University. Fourth edition.* 519 *pages,* 6 x 9 *in. Published by John Wiley & Sons, Inc.,* 440 *Fourth Ave., New York* 16, *N.Y.* $5.

In revising the third edition of this book, the author has undertaken to not only amplify and add current information on the design of mechanical components, but to present new problems in the form of new chapters on the form factor and strength of gear teeth, hydra-matic automobile transmissions, and strength and stiffness of shafts. The chapters on worm gearing and allowable stress have been entirely rewritten, and fifteen of the chapters have been revised.

In the introduction to each chapter, the author sets up the problems that will be treated. For example, in Chapter 6 on the valve gear of a diesel engine, the introduction states that the chapter "will deal with the valve gear of a Diesel engine, with the action and forces involved, and with the design of certain components. The cam will be designed, the design of the valve springs will be checked, the width of the cam will be determined, and the pushrod will be checked as a column."

Following the introduction is a discussion of the operation and principles of the mechanisms, the data for the problem, and the formulas and principles of design. References at the end of many of the chapters suggest sources for more detailed study of the problem.

Representative of the 26 chapters are those on strength and stiffness of shafts, curved parts and frames, pump problems, combination punch and



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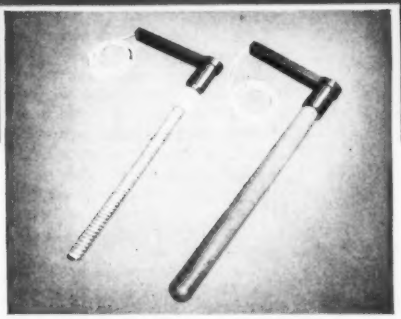

Amersil heater—fused quartz shell, and element wound with high heat and corrosion-resistant Nichrome V.

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Since quartz filters out a very small percentage of infra-red heat waves, and the heat source is immersed, almost 100% efficiency is obtained. Moreover, the unusually compact design of the installation offers the added advantage of cutting heater obstruction within the tank to a negligible minimum—permitting freer flow of liquids.

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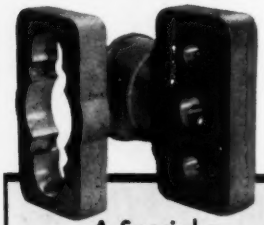

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Although essentially a text for college machine design and drafting room courses, much of interest to design engineers is included in the general discussions.

Metal Process Engineering

NORMAN E. WOLDMAN, *Consulting Metallurgical Engineer, First Edition. 291 pages, 6 x 9. Published by Reinhold Publishing Corp., 330 W. 42nd St., New York, N. Y. $5.*

This volume is concerned with the various practical phases of metallurgical engineering and metallurgical processes. The treatise was written to meet the needs of professional engineers and production men who will be able to use the information in their professional work. The subjects are approached metallurgically, but the plane of discussion is within the bounds of the basic metallurgical principles.

A large part of the book is devoted to the casting, forging and welding of metals. After treating these subjects individually, the advantages and disadvantages of each of the three are discussed with respect to various specific applications. The heat treatment chapter contains a section on designing parts for heat treatment, and also sets forth precautionary measures to be followed in production to prevent soft spots, warping and cracking during heat treating processes. The author has included an interesting report on the effects of microstructure and grain size on the machining of metals. This relatively new field in the science of metals should interest engineers who have occasion to design machined parts.

As the author says in his preface to the book, this work was largely derived from recent periodical publications. An amount of the information compiled has never before appeared in book form, and to supplement the subjects discussed, a list of periodical and book references are given at the end of each chapter.

Experimental Stress Analysis

Proceedings of the Society for Experimental Stress Analysis, Vol. VI, No. II, 158 pages, 8½ x 11 in. Published by Addison-Wesley Press, Inc., Kendall Square, Cambridge 42, Mass. $6.

Collection of 16 papers. Titles of papers with respective authors are: Bruce G. Johnston, "A Method for Vibration Fatigue Tests of Stranded

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Conductor"; J. M. Frankland, "Effects of Impact on Simple Elastic Structures"; G. E. Hudson, "A Method of Estimating Equivalent Static Loads in Simple Elastic Structures"; L. P. Zick and C. E. Carlson, "Strain Gage Survey Around the Supports of a 48-foot Diameter Hortonsphere"; E. W. Kammer and Sherwood Holt, Jr., "A Bonded Wire Strain Gage Type Accelerometer"; Gerald L. Rogers, "Sensitivity Chart for Wire Resistance Strain Gages"; Robert J. Hansen, "Controlled Impulsive-Load Testing Machine"; A. J. Durelli and T. N. DeWolf, "Law of Failure of Stresscoat"; William J. Eney, "A Large Displacement Deformeter Apparatus for Stress Analysis with Elastic Models"; William J. Eney, "Studies of Continuous Bridge Trusses with Models"; M. M. Leven, "Further Properties of Photoelastic Fosterite at Elevated Temperatures"; J. C. New, "An Example of Efficient Design Through Strain Measurements"; B. D. Haber, "Experimental Determination of Aircraft Loads"; A. M. Freudenthal, "Stress Analysis Beyond the Elastic Range"; C. C. Hsiao, "The Distribution of Residual Stresses in the Rolling Process"; J. P. Walsh and R. E. Blake, "The Equivalent Static Accelerations of Shock Motions".

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Patent Law

CHESTER H. BIESTERFELD, *Member of the New York and Delaware Bars, and of the Bar of the District of Columbia. Second Edition.* 339 *pages,* 9 x 6 *in. Published by John Wiley & Sons, Inc., Fourth Avenue, New York, N. Y.* $4.

This new edition covers changes that have occurred in patent law during the past five years, and also a number of important court decisions.

The author has endeavored to present a volume that:

1. Presents the basic principles of substantive patent law in terms that a general reader will understand.

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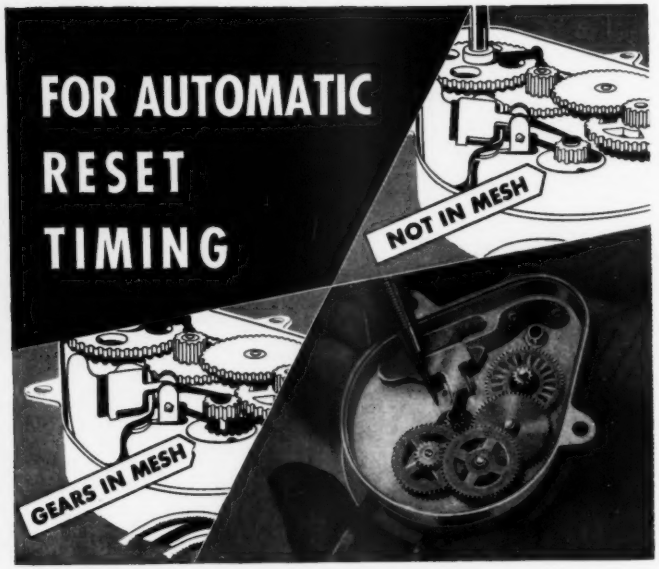

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elty, priority, originality, abandonment, claims, double patenting, reissues, disclaimers, interferences, infringements, liabilities and ownership, trade secrets, and patent litigation. The information, on Liability for Infringement has been extensively modified. Since Congress, in August, 1946, abolished recovery of profits, the previous discussion has been omitted and the author devotes more attention to the subject of damages.

Design for Welding

Edited by ROBERT S. GREEN, *Acting Chairman, Department of Welding Engineering, Ohio State University. Associate editors, Douglas C. Williams and Charles B. Smith, Engineering Department, Ohio State University.* 1024 *pages,* 5¾ x 8½ *in. Published by The James F. Lincoln Arc Welding Foundation, Cleveland* 1, *Ohio.* $2.

A collection of papers submitted in the Design for Welding Progress contest sponsored by The James F. Lincoln Arc Welding Foundation.

The book is sectionalized by industries and products, namely, automotive, aircraft, railroad, watercraft, containers, furniture, structures and machinery. In addition, there is a general section devoted to the organization and operation of welding departments. Each section consists of several papers on specific welding jobs supervised by the authors. For example, the chapters on automotive welding are:

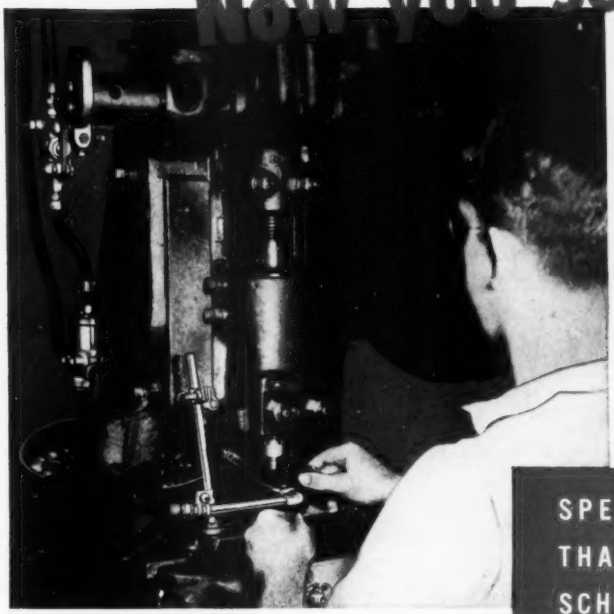
I Design of an All Welded Bus Body
II Bus Building—The Simple Way
III Application of Arc Welding in the Main Truss of the Greyhound GXI-50 Coach Structure
IV Custom Built Chasis for Export
V Helix Hauler
VI Casting vs Weld Fabrication

All chapters appear under the by-line of the author or authors who submitted the original paper.

Perhaps a better idea of the general treatment throughout the book can be obtained by examining a typical chapter in detail. In "Arc Welded Parts for Diesel Locomotive Engines," John H. Hruska discusses the welding of welded pistons, crankshafts, crankcases, generator frames, and truck frames for diesel engine locomotives. The general requirements for these components are brought out; and the materials, electrodes, and welding and heat-treating techniques used in producing them are described.

The strength of the book can be attributed to the unusually large number of case histories is included. The welding engineer probably will find

Now you see it PUFF... and it's done!



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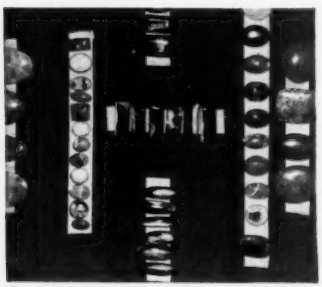

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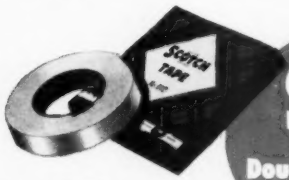

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Applied Mathematics for Engineers and Scientists

S. A. SCHELKUNOFF, *Bell Telephone Laboratories.* 472 *pages,* 6¼ x 9½ *in. Published by D. Van Nostrand Company, Inc., 250 Fourth Ave., New York 3, N. Y. Price* $6.50.

The purpose of this book is to bring applied mathematics up to date. The topics selected are those most frequently useful in various fields of science and engineering.

The book is divided essentially into two parts, one devoted to general mathematical methods and the other to special transcendental functions. The topics in the first part are arranged in the order of their difficulty.

Because of their importance in the theories of oscillations and waves, the second order differential equations are treated with particular thoroughness. Several sections of this chapter are devoted to the "Wave Perturbation Method", which is the most important practical method of obtaining analytic approximations to the solutions of these equations.

Special functions discussed include the Gamma Functions, Sine and Cosine Integrals, Fresnel Integrals, Bessel Functions. The last two are treated more thoroughly than has been customary in books of this type, in view of their increasing applications.

The last chapter on formulation of equations is intended to connect this volume with others on mathematical physics and mathematical engineering.

Industrial Experimentation

K. A. BROWNLEE. *Second Revised American Edition.* 168 *pages,* 5½ *x* 8½. *Published by Chemical Publishing Co., Inc., Brooklyn, N. Y.* $3.75.

This book is intended to be a guide to the planning and interpretation of experiments on an industrial scale. The book makes use of modern statistical methods, including tests of significance to attain reliability in deductions from experimental data, and the use of statistical design to attain the maximum precision with a minimum expenditure.

The subject matter is treated from a practical point of view and the only mathematics involved is simple arithmetic. Each statistical method discussed is illustrated with practical examples worked out in detail to show exactly what is involved in its use.

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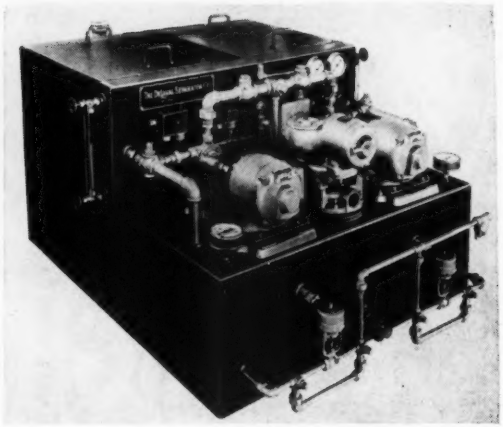

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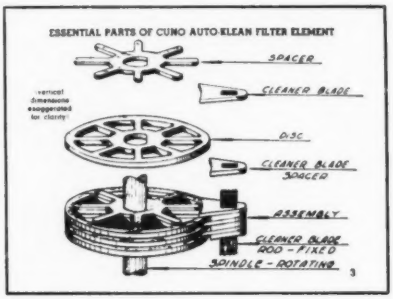

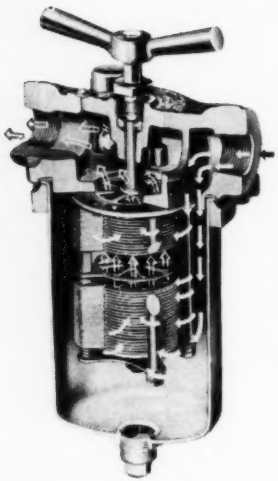

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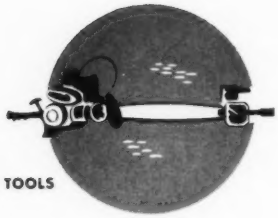

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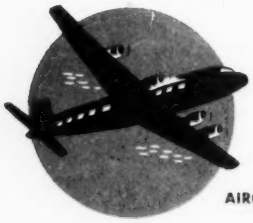

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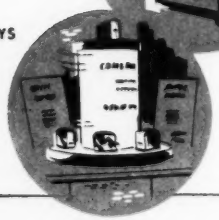

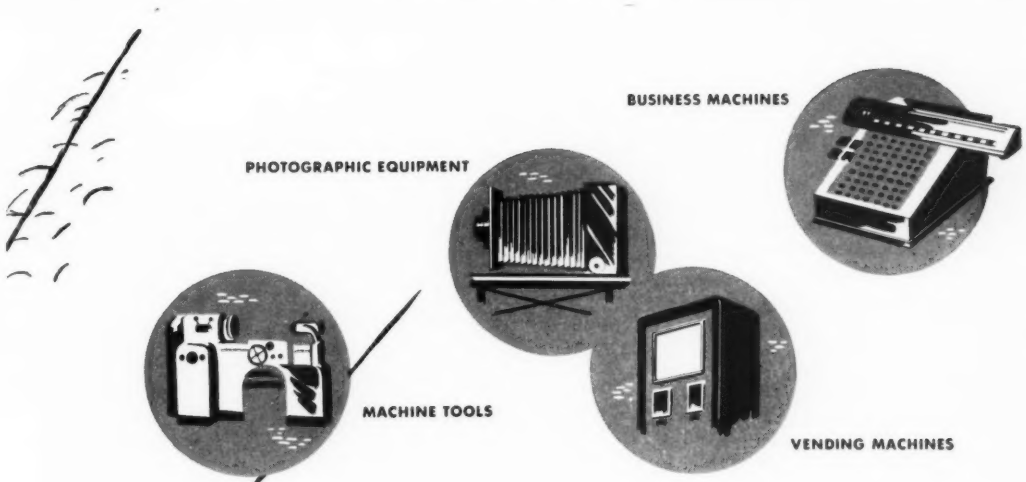

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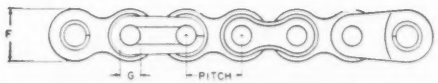
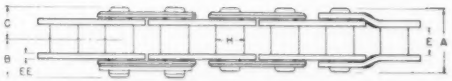
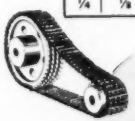




Principal Dimens.			LIST PRICES				DIMENSIONS — INCHES							
Pitch	Roller Width E	Roller Diam. H	Riveted Chain Per foot	Connecting Link Each	Assembled Roller Link Each	Offset Link Each	Overall Riveted A	From Pin End to C.L. B	From Pin Head to C.L. C	Side Plate Thickness EE	Side Plate Height F	Pin Diam. G	Average Ultimate Strength Lbs.	Average Weight per Foot Lbs.
¼	⅛	0.130	$1.10	$.14	$.10	$.40	0.31	0.19	0.15	0.030	0.23	.0905	875	.085



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By E. L. Alexander, Chief Engineer
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THROUGH the use of arc welded construction, the weight of our pump unit has been reduced from 1,475 pounds to 650 pounds. This saving of 825 pounds is important since the drilling unit on which the pump is used must be highly mobile. The drills are used for oil exploration work and for water well drilling. The pumps are designed for operation at 375 psi. The arc welded construction has eliminated sand holes, surface blemishes, and uneven metal distribution in cast parts. A recent cost analysis indicates the pumps will be produced at a saving.

The development of our all welded pump is typical of the general trend in the oil industry toward all welded machines and equipment. As a result of the greater durability to withstand severe service, many customers show a decided preference for arc welded steel construction.

Important to us also is the freedom for future design improvements and further cost reductions possible with arc welded construction. By discarding patterns and castings, we eliminate many of the cost restrictions that would otherwise limit progressive design changes in our products.

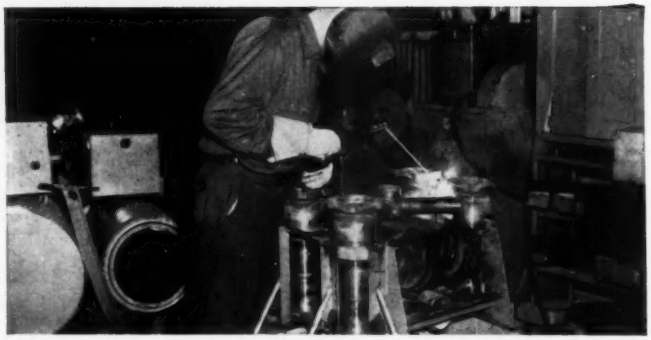

Fig. 1. Saves 825 pounds *by using welded steel construction on mud slush pump. Simple fixture is used to position parts with close fit-up for speedy welding.*

Component parts for our welded pumps are fabricated from flame-cut mild steel plate and from SAE 1020 cold drawn tubing. The two main units are the mud end shown in Fig. 2 and the power end shown in Fig. 3. These units are first fabricated as sub-assemblies in separate jigs and then arc welded in master jigs with "Fleetweld 5" electrode, using Lincoln "Shield-Arc" welders.

Fig. 2. Mud End Assembly. *Parts are fabricated from SAE 1020 cold drawn steel tubing with $\frac{3}{16}$" wall thickness; flanges are flame-cut from $\frac{7}{8}$" plate. Welds are $\frac{1}{4}$" or $\frac{3}{8}$", single and multiple pass, depending on the joint preparation.*

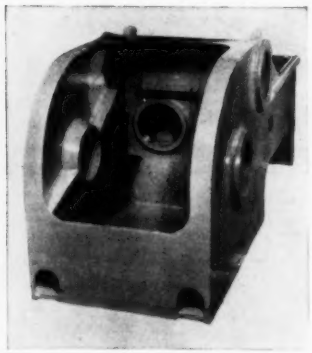

Fig. 3. Power End Housing. *Walls are flame-cut from $\frac{3}{16}$" steel plate. Bosses are machined from steel tubing and fillet welded to wall with $\frac{1}{4}$" "Fleetweld 5" electrode.*

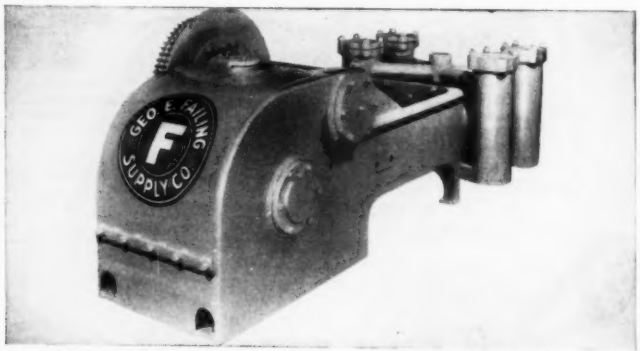

Fig. 4. All Welded Steel Pump *for well drilling operations. Light in weight and easy to move around . . . has corners rounded for "modern" appearance.*

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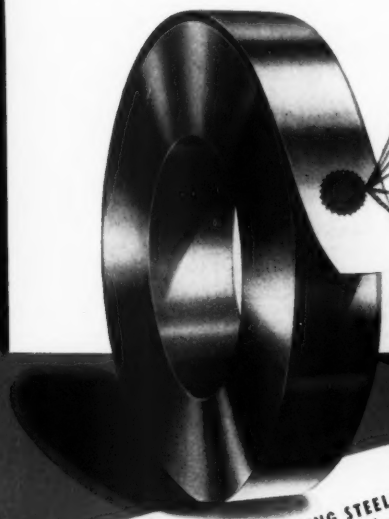

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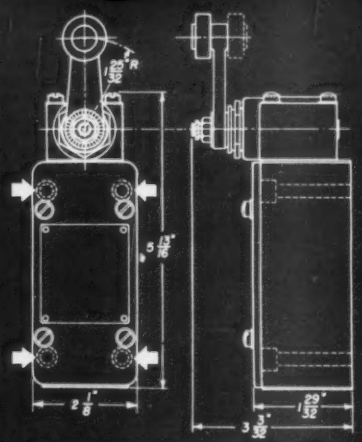
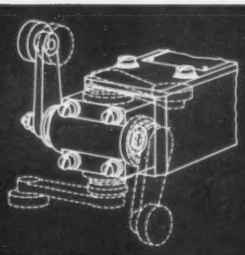
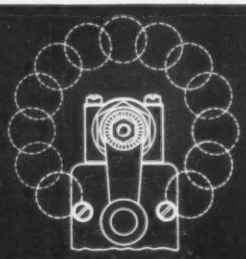


Four blind mounting holes for ¼" screws (shown by arrows) are provided in case—accessible with cover plate removed.

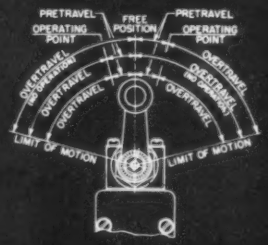


Operating head mounts in any of four positions shown. In addition, roller arm may be reversed as indicated.



Roller arm may be positively locked in any of 870 different positions at intervals of approximately 0.4°.

Operating shaft may be positioned for any one of the conditions of operation shown at right.



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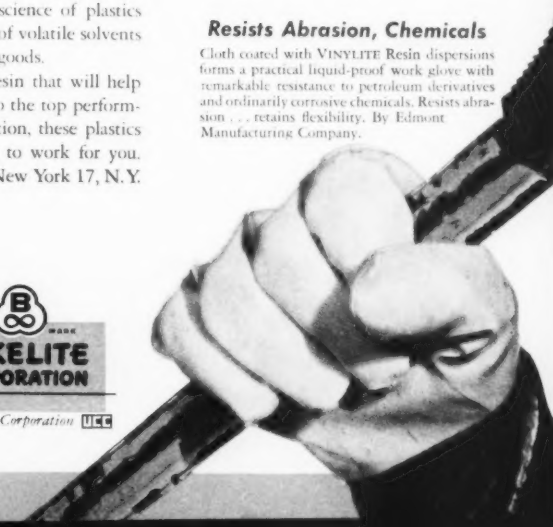

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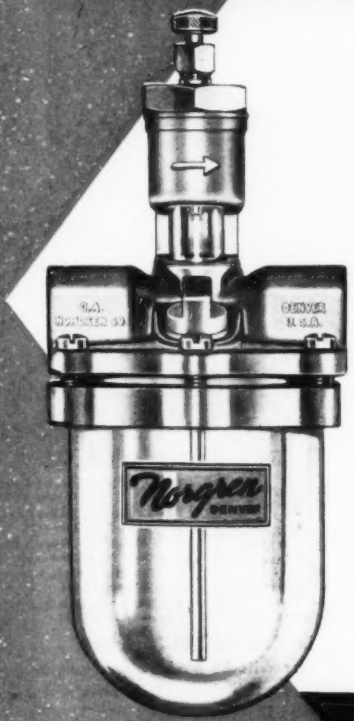

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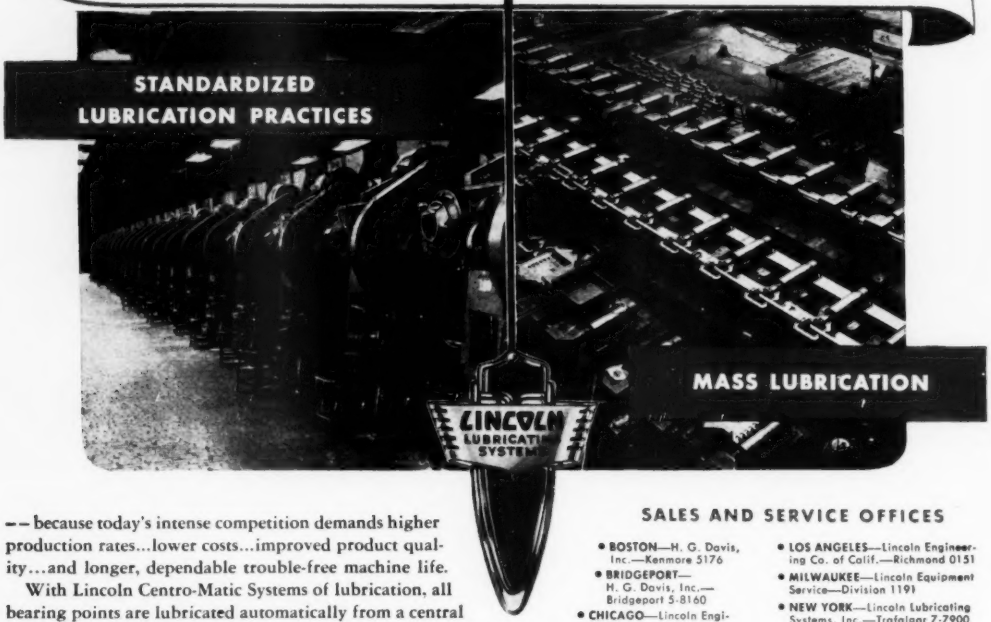

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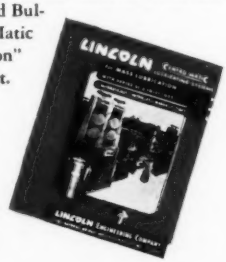

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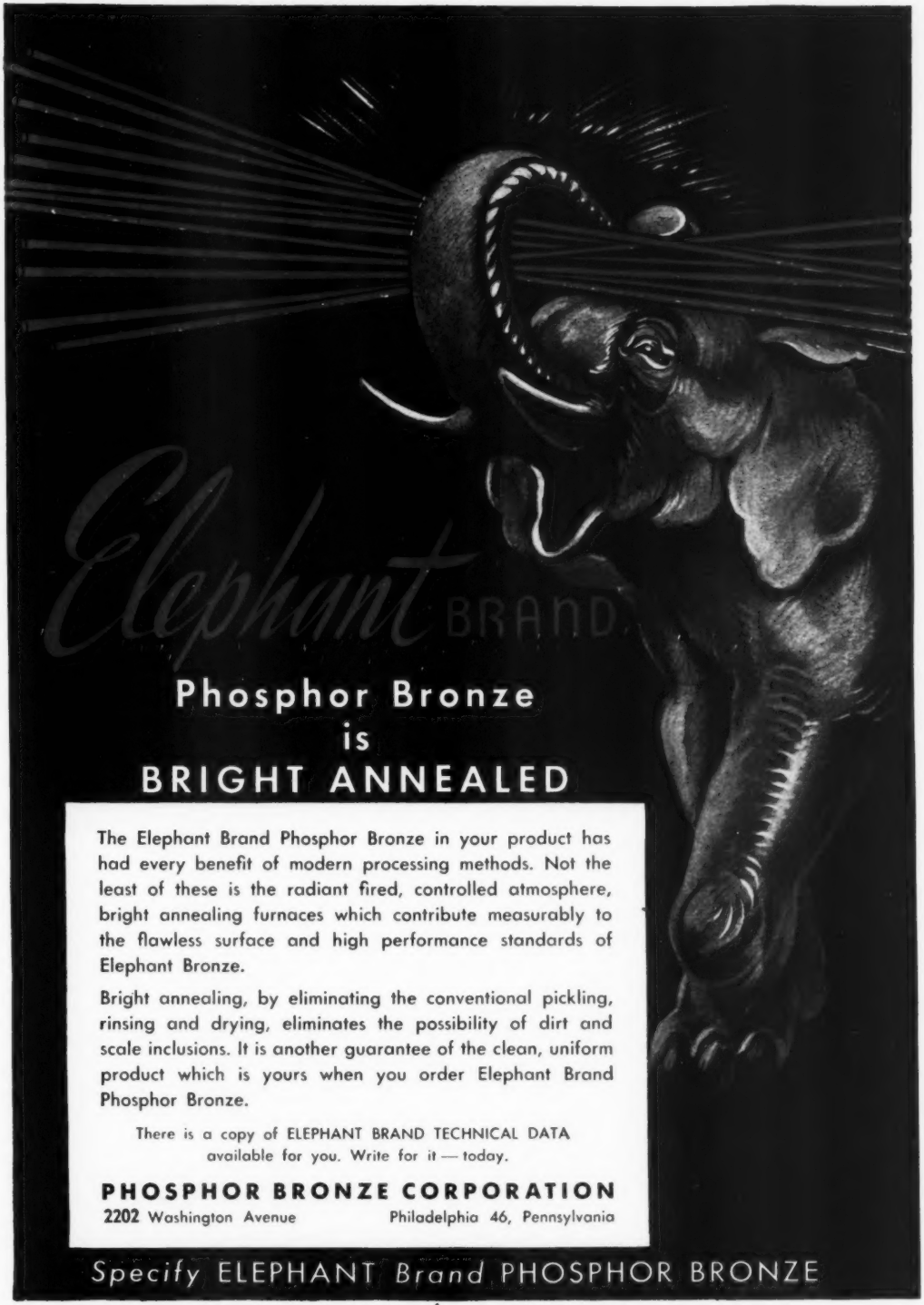

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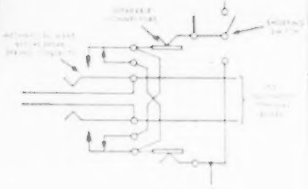

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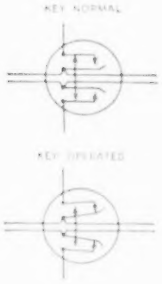

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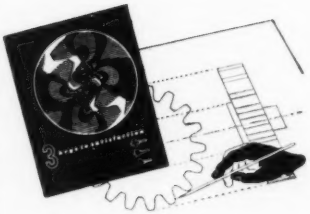

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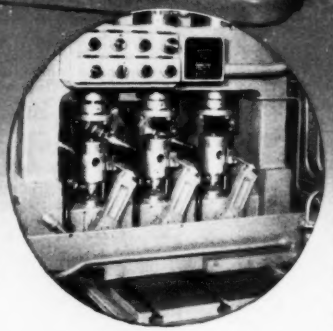
Ex-Cell-O Standard Machine with High Production Fixture—Bores Piston Wrist Pin Holes with .0003" Tolerance at Net Rate of 211 Pieces per Hour!



The right Fixture on Ex-Cell-O 112-C Precision Boring Machine provides hydraulic locating and clamping. Operation is tied in with machine cycle. The addition of two interchangeable sets of lower work centers and locating pins adapts the fixture for the whole group of pistons.

The Precision Boring Machine shown to left above (Ex-Cell-O Style 112-C) bores piston wrist pin holes at a rate of 211 pieces per hour, holding a tolerance of .0003" on the bore diameter, and providing a fine surface finish. The high production fixture accommodates a wide variety of similar pistons. Ex-Cell-O machines like this are also widely used for precision turning, facing and grooving operations. If your production involves parts like this, call your local Ex-Cell-O representative, or write Ex-Cell-O in Detroit today!

EX-CELL-O CORPORATION

40-9

DETROIT 32, MICHIGAN

Special Multiple Way-Type Precision Boring Machines • Special Multiple Precision Drilling Machines • Precision Boring, Turning, and Facing Machines and Fixtures • Precision Cylinder Boring Machines • Precision Thread Grinding Machines • Precision Lapping Machines • Precision Broach Sharpening Machines • Other Special Purpose Machines • Tool Grinders • Continental Cutting Tools • Breaches and Broach Fixtures • Counterbore Sets • Grinding Spindles Hydraulic Power Units • Drill Jig Bushings • R.R. Pins and Bushings • Fuel Injection Equipment • Dairy Equipment • Aircraft and Miscellaneous Production Parts

ACCURACY

STRENGTH

WEAR RESISTANCE

What *Qualities* do you look for in Non-Ferrous BEARINGS and CASTINGS?

You want ALL FOUR, of course . . . and you get ALL FOUR qualities plus better performance and greater long-range economy when you specify N-B-M Bearings and Castings.

SHOCK RESISTANCE

The bearings and castings shown above are typical results of these complete—and modern—facilities that you'll find at National Bearing Division:

Research—

American Brake Shoe's extensive research labs, containing the latest in testing equipment, are always at the disposal of N-B-M for all types of research on customers' problems.

Engineering—

The N-B-M Engineering staff is fully qualified to work either for or with you in solving problems of stress, alloy or over-all design of bearings and castings.

Production—

From precision molding to final machining, N-B-M has the latest manufacturing techniques that assure you of products with maximum strength, precision, wear-resistance and density.

Quality Control—

Modern X-Ray, Photomicrographing equipment, and other latest testing devices provide a surety for you of castings that meet and often exceed your specifications.

Yes, if qualities that insure longer, more economical service are important for the Bearings and Castings used in your plant or product, call in your nearest N-B-M Representative. He will be glad to give you specific information on how this complete N-B-M service can be applied to your problems.

NBM

AMERICAN Brake Shoe COMPANY

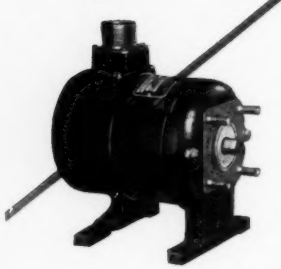
NATIONAL BEARING DIVISION

4930 Manchester Avenue • St. Louis 10, Mo.

PLANTS IN: ST. LOUIS, MO. • MEADVILLE, PA. • NILES, OHIO • PORTSMOUTH, VA. • ST. PAUL, MINN. • CHICAGO, ILL.

Designing For Leadership..

WITH Lamb Electric MOTORS



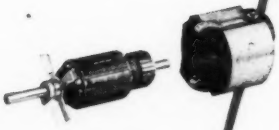
Intermittent high torque motor with low weight factor is adaptable to many general applications.

Knowing the importance of efficient, dependable motor operation in winning product leadership, more and more design engineers are specifying Lamb Electric Motors.

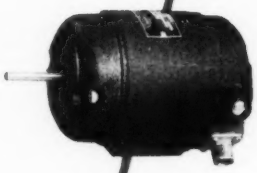
Specially engineered for each product or device, Lamb Electric Motors provide the exact mechanical and electrical requirements for a specific application.

Our 34 years' experience in motor engineering frequently enables us to make product design suggestions which reduce *product* weight, provide compactness, improve performance, and lower cost.

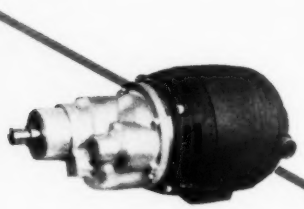
THE LAMB ELECTRIC COMPANY
KENT, OHIO



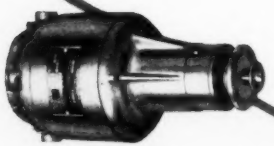
Series universal motor parts specially designed for food-mixers and sewing machines.



This small, sturdy motor can be readily adapted to a wide range of industrial applications.



Light-weight universal motor with efficient spur gear speed reducer for many types of portable equipment.



Universal motor with shaft carried on double row ball bearings, developed for use as a high-speed grinder.

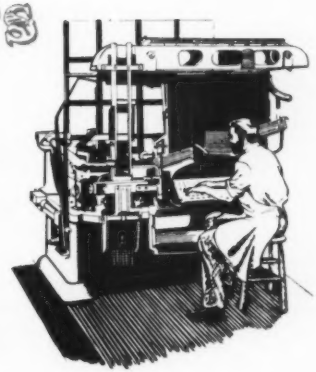
Lamb Electric
SPECIAL APPLICATION FRACTIONAL HORSEPOWER MOTORS

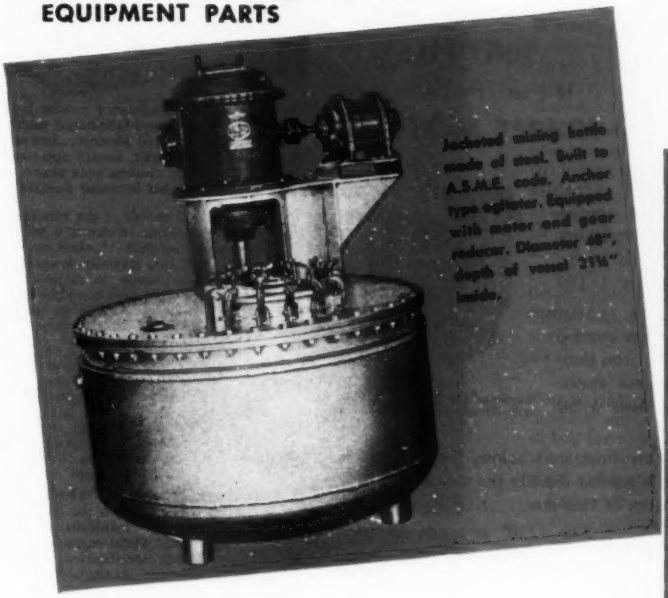
BACK IN THE 1880's

WHEN MERGENTHALER INVENTED
THE LINOTYPE MACHINE

Koven

WAS MAKING INDIVIDUALIZED
EQUIPMENT PARTS



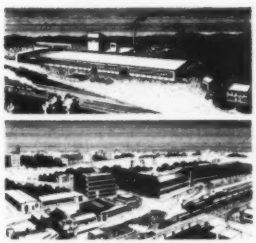


Jacketed mixing kettle made of steel. Built to A.S.M.E. code. Anchor type agitator. Equipped with motor and gear reducer. Diameter 48", depth of vessel 31½" inside.

Vacuum vessel made of steel. Anchor type agitator. Hollow shaft with thermometer tube extending to bottom. Diameter 12", overall height 18".

If you are an equipment manufacturer, KOVEN'S vast experience in the fabrication of individualized equipment parts can help you. Because KOVEN engineers and craftsmen have specialized in serving the requirements of leading builders of equipment for over 68 years, they have developed efficient, economical methods that enable them to turn out a part or parts of the finished product you require in less time and often at a lower cost than they could be made in your own plant. Call or write today for a consultation with one of our representatives—no obligation. Our two modern plants are equipped with machine, welding, plate and sheet metal, galvanizing and painting shops. X-ray inspection insures quality control.

L. O. KOVEN & BRO., Inc., 154 Ogden Ave., Jersey City 7, N. J.



Plants:
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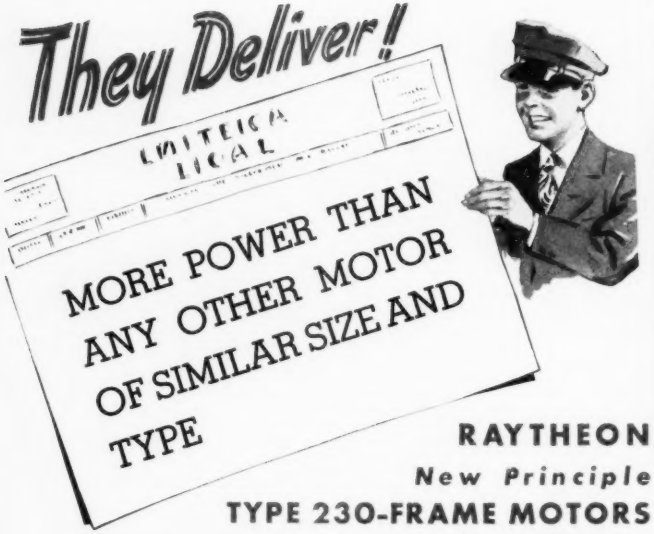


RAYTHEON

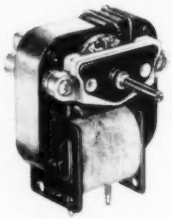
New Principle

TYPE 230-FRAME MOTORS

HERE ARE THE FACTS

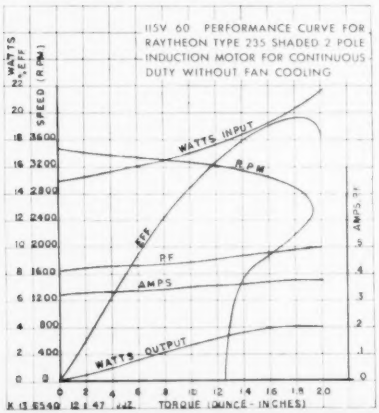
Type 235, 1/200 H.P. at 3000 rpm continuous duty without fan cooling, 5/8" iron lamination stacking, 2 3/8" square frame stator core. With fan cooling it will deliver 1/150 H.P. at 3200 rpm.

Type 239, 1/125 H.P. at 3000 rpm continuous duty without fan cooling, 1 1/8" iron lamination stacking, 2 3/8" square frame stator core. With fan cooling it will deliver 1/50 H.P. at 3200 rpm.



Raytheon 230 De Luxe Model with die-cast bearing brackets.

As shown on the performance curve illustrated below, the efficiency of Raytheon "230"-Frame motors is almost double the value ordinarily obtained in shaded 2-pole motors of this size.



The "230" is made in two types: *De Luxe Model*, with die-cast bearing brackets, dynamically balanced, for phonographs, wire and tape recorders, sound projectors and other high quality applications.

Economy Model, with brass strap bearing brackets, for desk fans, toys, electric heater fans, projector cooling blowers, slide projectors and similar uses.

Bulletin 1000 gives complete data and illustrations. Write today for your copy.

RUSSELL ELECTRIC COMPANY

Subsidiary of Raytheon Mfg. Co.

4501 So. Western Blvd. Chicago 9, Illinois

Special Message to Product Engineers

NEW TEST-TANK SAVES 50% AND INCREASES MARKET

How an entire industry profits by Stolper-designed-and-fabricated tank for testing Outboard Motors...lower cost, lighter weight, smart appearance and greater convenience among ten advantages that increase demand

Here is a typical sample of the versatile and profitable Stolper service to a wide variety of manufacturers . . . sheet metal parts and assemblies, specially designed, or fabricated exclusively to customers' specifications. Stolper *adds* complete design and fabricating facilities to your plant *without adding to your payroll.*

Every sales outlet for outboard motors needs a test-tank for demonstration and motor adjustment. Cost of previous designs, provided either by manufacturers individually or "home-made", have absorbed the entire profits from two to four outboard motors. The above design, skillfully engineered, costs less than the profit from a single outboard motor.

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If you have, here's what to do: Submit your requirements for confidential analysis by Stolper Sheet Metal engineers . . . or send blueprints, specifications (and your volume forecast, if available) for quotations.

Get this FREE Book. Stolper is America's foremost contract fabricator of sheet metal . . . serving the leaders in the nation's metal working industry. You'll want this FREE booklet, "STOLPER, Your Sheet Metal Department". USE THE COUPON.

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Koppers Polystyrene 8

FOR THE BEST COMBINATION OF ELECTRICAL, THERMAL AND CHEMICAL PROPERTIES

INSTRUMENT CASE

Molded of Koppers Polystyrene because of its excellent electrical properties and low cost. Made by Industrial Devices, Inc., Edgewater, N. J.

PYROMETER CASE

Molded of Koppers Polystyrene 8 to obtain extra heat resistance, add crystal clarity combined with good dimensional stability to assure a close-fitting cover. Molded by Majestic Molding Co., Elyria, Ohio, for Assembly Products Inc., Chagrin Falls, Ohio.

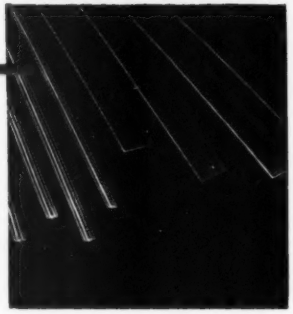

PLATE SEPARATORS

Used to separate the positive and negative plates of "NICAD" Alkaline storage batteries. Extruded Koppers Polystyrene 8 was used for its high resistance to chemical deterioration, extra heat resistance, plus its high electrical insulating properties. Supplied by R. E. Hartung Co., Inc., New York City for Nickel-Cadmium Battery Co., Easthampton, Mass.

● Compare these properties of Koppers Polystyrene 8 with those of other rigid plastics and other polystyrenes. You'll find Koppers Polystyrene 8 offers the best combination of properties for many electrical and mechanical applications.

ELECTRICAL PROPERTIES. Koppers Polystyrene 8 is unsurpassed, with the highest dielectric strength and the lowest power factor.

THERMAL PROPERTIES. Koppers Polystyrene 8 is among the highest in heat distortion temperature of all commercially available polystyrenes—minimum 200°F. under the A.S.T.M. Test D 648-45T. Polystyrenes, as a class, have the lowest thermal conductivity of the common plastic molding materials.

CHEMICAL PROPERTIES. Polystyrenes rate first in resistance to water and all concentrations of acids and alkalies.

This combination of properties—excellent electrical characteristics, improved heat resistance and superior chemical properties makes Koppers Polystyrene 8 first choice for numerous electrical applications including television insulators, instruments, meters, battery cases and many parts of appliances.

Add to this an unlimited choice of colors plus a faster molding cycle and low price and you can see why Koppers Polystyrene 8 is rapidly becoming the most widely used plastic molding material.

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Chemical Division
Regional offices in New York, Chicago and San Francisco

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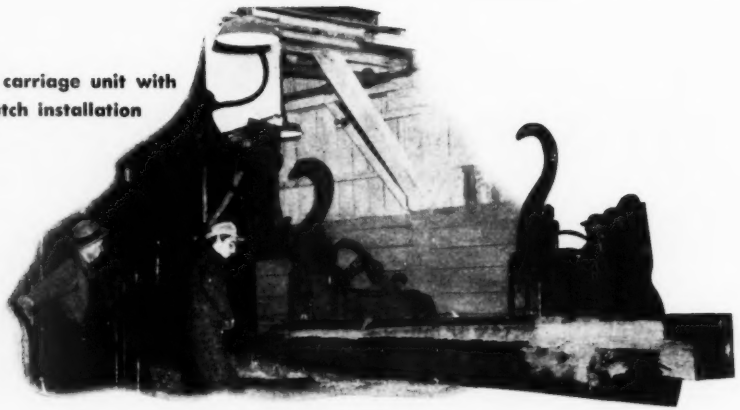
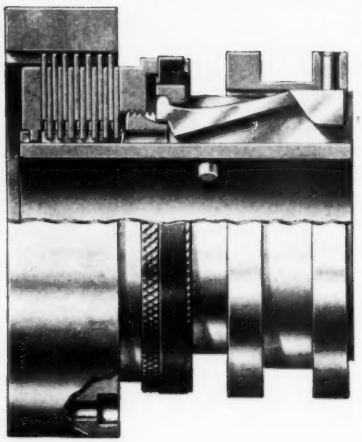
Koppers *Perfected* Plastics

*POLYSTYRENE *ETHYL CELLULOSE *CELLULOSE ACETATE

ALLIS-CHALMERS saw mill carriage unit with Maxitorq Floating Disc Clutch installation



MAXITORQ



Capacities to 15 H.P. at 100 R.P.M. . . . single or double, wet or dry. Clutch shipped completely assembled ready to slip onto shaft. Also in pulley and cut-off coupling types.

. . . keeps Good Company

The Maxitorq No. 27 10 H.P. double dry clutch (2¾" bore) performs a vitally important job in this Allis-Chalmers band head rig in the new mill of Willamette National Lumber Co., Foster, Oregon.

Working large logs (to 35,000 lbs.) requires overcoming of considerable static friction in starting the log advance to set position. Then, the skilled operator must sense and feel decreasing changes in force in a few seconds as he holds the clutch lever. The Maxitorq, with non-locking levers, provides the sensitive and protective release so necessary.

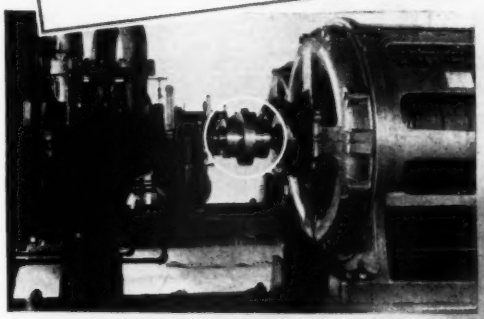
Maxitorq was selected by Allis-Chalmers when other units proved unsatisfactory . . . and naturally we are proud to be in such "good company." Can we help you?

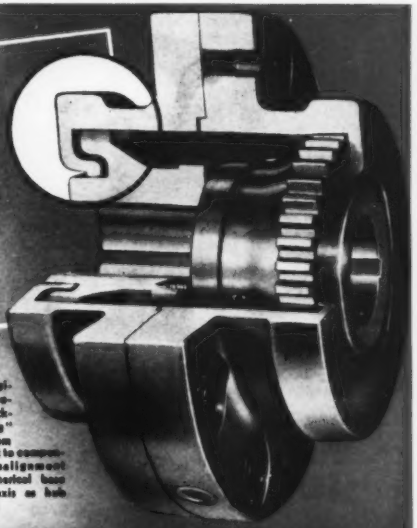
Send for Catalog No. PE5

SCJ49

THE CARLYLE JOHNSON MACHINE COMPANY
MANCHESTER • CONNECTICUT

How Fast's Exclusive Metal to Metal Seal Boosts Your Plant's Production





Correctly engineered oil-protecting "rocking bearing" allows freedom of movement to compensate for misalignment because spherical face has same axis as hub spline faces!

OIL REFINERIES insist on Fast's Couplings to *keep* their vital machinery *running*, because they know Fast's virtually *eliminate* all shutdowns due to coupling failure! This Coupling has been in service since 1931.

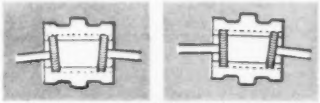
HEAVY INDUSTRIES specify Fast's Couplings because they compensate for shaft misalignment and have *no perishable parts* of any kind to fail!

YOUR production figures *go up* and *stay up* when your vital equipment is protected with Fast's Couplings, because Fast's virtually eliminate all shutdowns due to coupling failure. Fast's use no perishable parts or packing rings . . . they are the *original* gear-type coupling that *really* guards load-carrying oil from moisture, abrasive dust and grit! Fast's have *exclusive* "rocking bearing" principle that gives *sure* metal-to-metal seal.

When you specify Fast's you get years of top engineering experience, Koppers' high standard of workmanship, and unexcelled coupling service including available parts if required by change of drive, *even if your Fast's have been running for 30 years*. You save money, eliminate bottlenecks with Fast's on the job, because machine and motor life is prolonged, upkeep costs are cut, shutdown losses reduced. Find out about Fast's! Use the handy coupon, or write today for free catalog. Address: Koppers Co., Inc., Fast's Coupling Dept., 275 Scott Street, Baltimore 3, Maryland.

FAST'S COUPLINGS COMPENSATE FOR ALL MISALIGNMENT

The floating sleeve takes a neutral position. All forms of misalignment are compensated for between the lubricated faces of the splines, equally divided between the driving and driven members. The entire assembly revolves as one unit.



The above exaggerated diagrams demonstrate the Fast's principle.

KOPPERS **FAST'S** *Self Aligning* **COUPLINGS**

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KOPPERS CO., INC., FAST'S COUPLING DEPT.,
275 Scott Street, Baltimore 3, Md.

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5. **STEEL** — H-K special analysis heat-treated alloy.
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RESULT — **GUARANTEED UNFAILING PERFORMANCE.**

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THE HOLO-KROME SCREW CORP. HARTFORD 10, CONN.

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(1) MICRONIC FILTERS—Greer Hydraulics, Inc., 454 18th St., Brooklyn 15, N. Y. Bulletin, 8 pages. Explains installation, operation, and gives sizes and specifications for micronic filters used in hydraulic systems.

(2) INDUSTRIAL FURNACES—Surface Combustion Corp., Toledo 1, Ohio. Folder SC-141, 8 pages. Describes and illustrates furnaces for such applications as hardening, tempering, forging, and air heating. Gives rated performances and shows parts in stock.

(3) FOUR-WAY VALVES—Vickers, Inc., 1400 Oakman Blvd., Detroit 32, Mich. Bulletin, 12 pages. Shows design features and operation of Series DG solenoid controlled valves for oil hydraulic circuits with installation drawings and specifications to aid in selection.

(4) PERMANENT MAGNETS—General Electric Co., Chemical Div., Pittsfield, Mass. Catalog CDM-2A, 28 pages. Includes photographs, pull curves and property tables that describe variously shaped permanent magnets for various industrial applications.

(5) RESEARCH PAPER — Silverstein-Pinsof, Inc., 1720 Elston Ave., Chicago 22, Ill. Booklet, 6 pages. Contains information on the colorimetric determination of aluminum in zinc-base die casting alloys.

(6) PNEUMATIC WHEELS—Saginaw Products Corp., Saginaw, Mich. Folder, 6 pages. Gives tire, shell, and wheel specifications for pneumatic wheels and casters used on industrial machinery.

(7) ELECTRO-MAGNETIC CONTROLS—Automatic Switch Co., 291 Lakeside Ave., Orange, N. J. Catalog 700, 16 pages. Contains descriptions and illustrations concerning automatic transfer and remote control switches along with discussions of ratings and designs for contactors, relays and specialized controls.

(8) SPEED REDUCERS — Farrel-Birmingham Co., Inc., 344 Vulcan St., Buffalo 7, N. Y. Bulletin 449, 40 pages. Describes herringbone-geared speed reducers and gives tables of service factors, character of load, hp ratings, overhung load capacities and dimensions.

(9) OIL SEALS—Chicago Rawhide Mfg. Co., 1201 Elston Ave., Chicago 22, Ill. Catalog 947, 44 pages. Presents a discussion on designing for oil seals, and illustrates and gives specifications for 12 different types of oil seal design.

(10) TENITE SPECIFICATIONS—Tennessee Eastman Corp., Kingsport, Tenn. Catalog, 42 pages. Gives results of tests conducted on Tenite cellulose ester plastics as set forth in a series of charts and graphs to show physical and chemical properties.

(11) WIRE ROPE—Jones & Laughlin Steel Corp., Wire Rope Sales, Pittsburgh 30, Pa. Handbook, 96 pages. Colorfully presents information on the operation, selection, construction, recommendations for use and standardized fittings used with all rope sizes.

(12) TESTING MACHINES FOR PLASTICS—Tinius Olsen Testing Machine Co., 1084 Easton Rd., Willow Grove, Pa. Bulletin 36, 36 pages. Shows specifications, explanatory charts and photographs to illustrate designs of machines for testing the physical properties of plastics.

(13) CHEMICAL RESISTANT COATINGS—Carboline Co., 7603 Forsyth Blvd., St. Louis 5, Mo. Bulletin C-2, 4 pages. Describes cements and coatings to protect metals against various acids, alkalis and solvents.

(14) INSTRUMENT GUIDE—Taylor Instrument Co., Rochester 1, N. Y. Bulletin 98170, 16 pages. Presents information on complete line of instruments for testing temperature, humidity, pressure, flow, liquid level, force and time cycles.

(15) CHAINS & SPROCKETS—Cullman Wheel Co., Inc., 1344 Altgeld St., Chicago 14, Ill. Catalog 48, 80 pages. Illustrates and offers technical data on roller block, silent chains and variously applied chain sprockets along with specifications to aid in selection.

(16) INDUCTION MOTORS — Allis Chalmers Mfg. Co., Box 512, Milwaukee 1, Wis. Bulletin 51B6144, 4 pages. Gives information on applications and construction of Type ARZ totally inclosed induction motors.

(17) SHEET METAL PRODUCTS—Cincinnati Metalcrafts, Inc., 34th & Robertson Ave., Cincinnati 9, Ohio. Bulletin, 12 pages. Presents a picture of the company's equipment for producting various structural parts to house machine members.

(18) TURBO PUMPS—J. S. Coffin, Jr., Co., 326 S. Dean St., Englewood, N. J. Bulletin S, 4 pages. Describes types CC and CG pumps to be used with such equipment as steam turbines, boilers, and hydraulic feed applications.

(19) SEALING CAPS & SLEEVES—General Electric Co., Plastics Div., Pittsfield, Mass. Folder CDP-589, 6 pages. Describes the applications for sealing caps and sleeves in the air conditioning, refrigeration, packaging and electrical fields.

(20) HYDRAULIC ACCUMULATORS—Greer Hydraulics, Inc., 454 18th St., Brooklyn 15, N. Y. Bulletin, 8 pages. Gives information on construction, operation, application, and performance characteristics of seven standard size hydraulic cylinders for storing fluid energy.

(21) INDUSTRIAL TIRES—General Tire & Rubber Company, Industrial Tire Division, Akron, Ohio. Catalog, Form 2357, 15 pages. Illustrated brochure on the selection of wide base rim pneumatic and solid tires. Specifications for selection of rims, wheels and castor forks, as well as the two types of tires are given.

(22) FLEXIBLE SHAFTING — Elliott Mfg. Co., 350 State St., Binghamton, N. Y.

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Catalog 49, 16 pages. Explains construction details and describes operation of different types of flexible shafting for such uses as power takeoffs and remote control of valves.

(23) ELECTRO-GALVANIZING — Republic Steel Corp., 3100 E. 45th St., Cleveland 4, Ohio. Bulletin ADV-525, 12 pages. Information on welding, soldering, painting and uses of electro-zincplated sheets with data on gages, sizes and base metals available.

(24) CONTACT RIVETS — Gibson Electric Co., 8350 Frankstown Ave., Pittsburgh 21, Pa. Catalog C-12, 6 pages. Included is a description of the electrical contact materials in which rivets are furnished, as well as sizes of flat, crowned and pointed heads available.

(25) CENTRIFUGAL PUMPS — Byron Jackson Co., Pump Div., Terminal Annex Box 2017, Los Angeles 54, Cal. Bulletin 48-4000, 16 pages. Offers information on centrifugal pumps with 2, 4, 6 or 8 stages that have capacities for 100 to 4,000 gallons per minute.

(26) STEEL MAKING—Inland Steel Co., 38 S. Dearborn St., Chicago 3, Ill. Booklet, 64 pages. A well illustrated story of the making of steel, with sections on galvanizing, timing, quality control and special purpose steels.

(27) WELDING STAINLESS STEEL — The Lincoln Electric Co., Cleveland 1, Ohio. Bulletin 463, 8 pages. Gives applications, procedures and properties of deposited metal used for welding stainless steel.

(28) AIR CONTROL VALVE — Hannifin Corp., 1101 S. Kilbourn Ave., Chicago 24, Ill. Bulletin 230, 4 pages. Shows construction, operation and uses for disk type, 4-way, air control valve.

(29) TIMING DEVICES — Hansen Mfg. Co., Inc., Princeton, Ind. Catalog 47, 12 pages. Offers information on the performance, uses and design of synchronous timing motors, timing machines, and the "Permag" d-c motors for instruments.

(30) WELD STUDS—Nelson Stud Welding Div., Morton Gregory Corp., Lorain, Ohio. Leaflet, 4 pages. Contains dimensions and prices of line of 60 standard studs designed for end welding along with illustration showing special purpose studs.

(31) LOCKNUTS AND LOCKWASHERS —Standard Locknut & Lockwasher, Inc., 309-311 N. Capitol Ave., Indianapolis 4, Ind. Bulletin 27, 6 pages. Gives specifications for locknuts and lockwashers used to hold ball or roller bearing assemblies.

(32) PYROMETER MANUAL—The Bristol Co., Waterbury 91, Conn. Bulletin P1238, 56 pages. Information on thermocouples, protection tubes, and other pyrometer accessories. Contains tables of calibration data for base metal and rare metal thermocouples.

(33) GEAR MOTORS—Janette Mfg. Co., 556 W. Monroe St., Chicago 6, Ill. Brochure 3-200, 4 pages. Gives dimensional data, ratings and description of foot and flange mounted type UW gearmotors.

(34) SYNTHETIC RUBBER—B. F. Goodrich Chemical Co., 324 Rose Bldg., Cleveland 15, Ohio. Brochure, 24 pages. Includes sections on compounding process, fabrication, physical properties and uses of Hycar rubber as a component in product designs.

(35) INDUSTRIAL CASTERS — Albion Industries Inc., Albion, Mich. Catalog, 32 pages. Shows design and specifications of casters with rubber, plastic and semi-steel wheels for heavy, medium and light duty.

(36) CONTRACT FORMING—The Cyril Bath Co., Metal Form Div., E. 70th & Machinery Ave., Cleveland 8, Ohio. Brochure, 12 pages. Shows methods, production facilities and typical parts made by stretch and compress forming in lots from 100 to 100,000 pieces.

(37) SOLDER MANUAL—Kester Solder Co., 4201 Wrightwood Ave., Chicago 39, Ill. Booklet, 26 pages. Devoted to an analysis of properties and applications of soft solder alloys and soldering fluxes.

(38) WORM GEAR SPEED REDUCER—The Cleveland Worm & Gear Co., 3293 E. 80th St., Cleveland 4, Ohio. Bulletin, 8 pages. Describes six typical applications in which Speedaire reducers have saved in space, weight and cost.

(39) MOTOR STARTERS — Allis-Chalmers Mfg. Co., S. 70th St., Milwaukee, Wis. Bulletin 14B7132, 12 pages. Describes construction details and uses of line of a-c full voltage starters to meet requirements of any type of motor drive.

(40) HYDRAULIC CYLINDERS — Gerotor May Corp., Baltimore 3, Md. Catalog section 103, 18 pages. Presents information on all standard cylinders with diagrams and guides to aid in circuit layout.

(41) INSULATION TESTERS—James G. Biddle Co., 1316 Arch St., Philadelphia 7, Pa. Bulletin 21-20-32, 24 pages. By means of illustrations, charts and diagrams, bulletin explains operation, construction and uses of "Megger" instruments for testing electrical equipment.

(42) CORROSIVE RESISTANT LINING —Metalweld Inc., 26th & Hunter Park Ave., Philadelphia 29, Pa. Folder, 4 pages. Discusses application and corrosion resistance of synthetic elastic material, Koroseal, for lining of chemical, acid and plating tanks.

(43) DECAL NAME PLATES — The Meyercord Co., 5323 W. Lake St., Chicago 44, Ill. Catalog, 18 pages. Gives information about selection of decal type for such applications as dial and gage markings, inspection data and operating instructions.

(44) SYNCHRONOUS GENERATORS — Elliott Co., Electric Power Dept., Ridgway, Pa. Bulletin PB 2400-1, 4 pages. Devoted to explanation of construction details and mechanical modifications of newly designed generators.

(45) ELECTRONIC RECORDERS — Bailey Meter Co., 1050 Ivanhoe Rd., Cleveland 10, Ohio. Bulletin 221-A, 12 pages. Describes and shows pictures and circuit diagrams of recorders for measuring temperature, pressure, fluid flow, liquid level, speed, and smoke density.

(46) METAL PUNCHING UNITS — Wales-Strippet Corp., 345 Payne Ave., North Tonawanda, N. Y. Catalog BL, 31 pages. Shows design details of punch units which can produce innumerable punch patterns in sheet steel up to ¼ in. thick.

(47) TACHOMETERS — Metron Instrument Co., 432 Lincoln St., Denver 9, Col., Bulletin 104, 4 pages. Explains operation of several tachometers, gives ratings, and shows a basic electric circuit diagram.

(48) INSULATION MATERIALS — The Celotex Corp., 120 S. La Salle St., Chicago 3, Ill. Reference file, 29 pages. Folder contains information bulletins which describe and illustrate various kinds of materials for insulating a product against sound, heat, cold and other undesirable atmospheric conditions.

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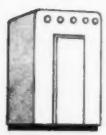

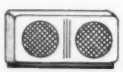

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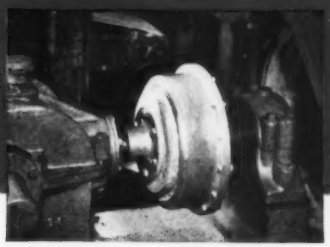
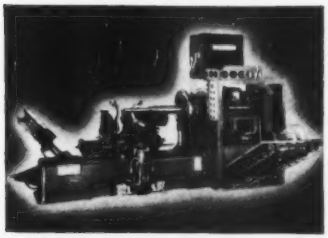
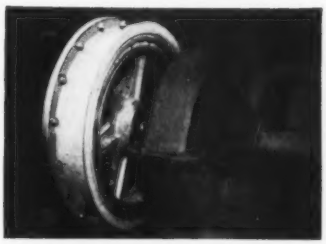


Fawick Airflex element used on Suction Press Drive at Crane & Co., Inc., Dalton, Mass.



Fawick Airflex element used on Passenger Tire Building Machine by National Rubber Machinery Co., Columbiana, Ohio.



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The rubber-and-fabric pneumatic tube faced with friction shoe assemblies is the only moving part in this Fawick Clutch. This part naturally stays in perfect adjustment at all times—automatically compensating for wear of the friction shoes.

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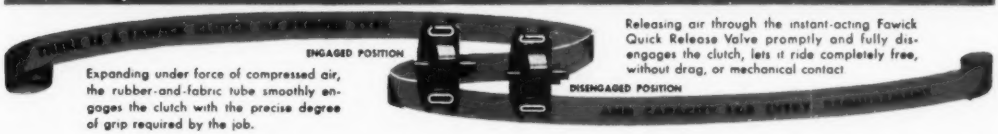

Expanding under force of compressed air, the rubber-and-fabric tube smoothly engages the clutch with the precise degree of grip required by the job.

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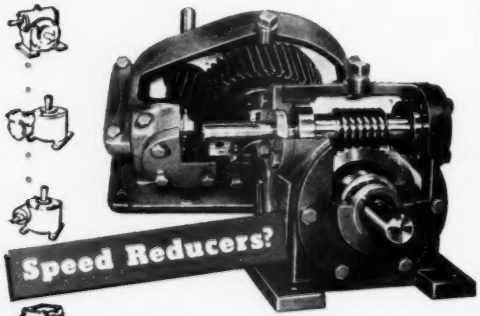

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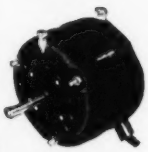

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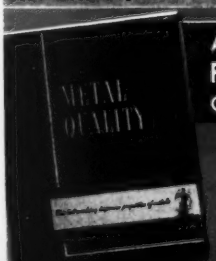

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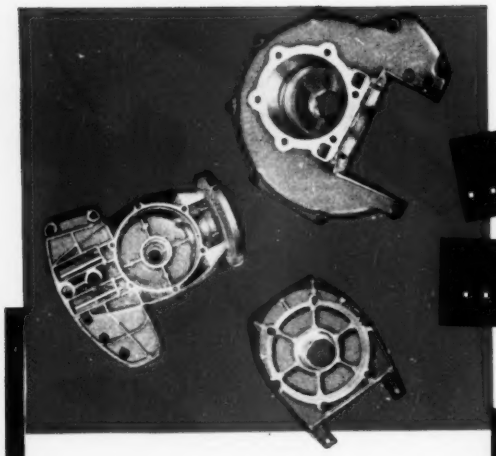

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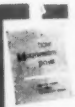

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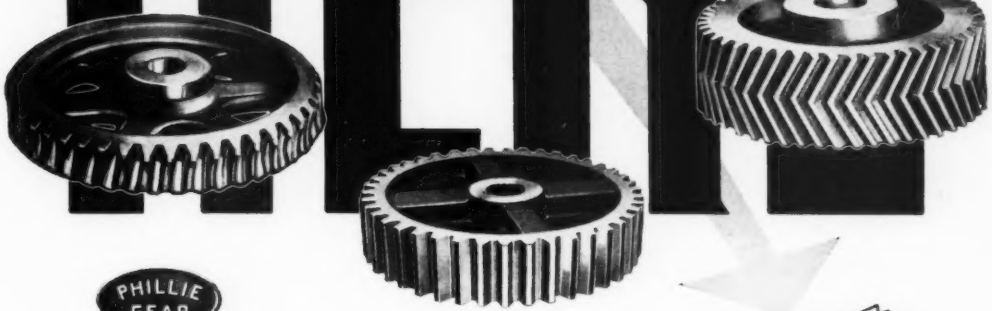

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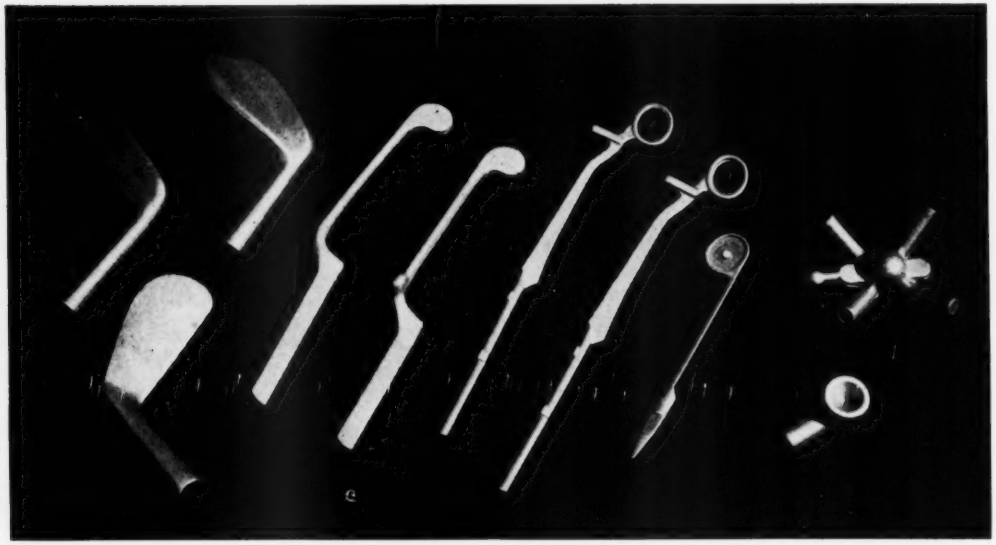

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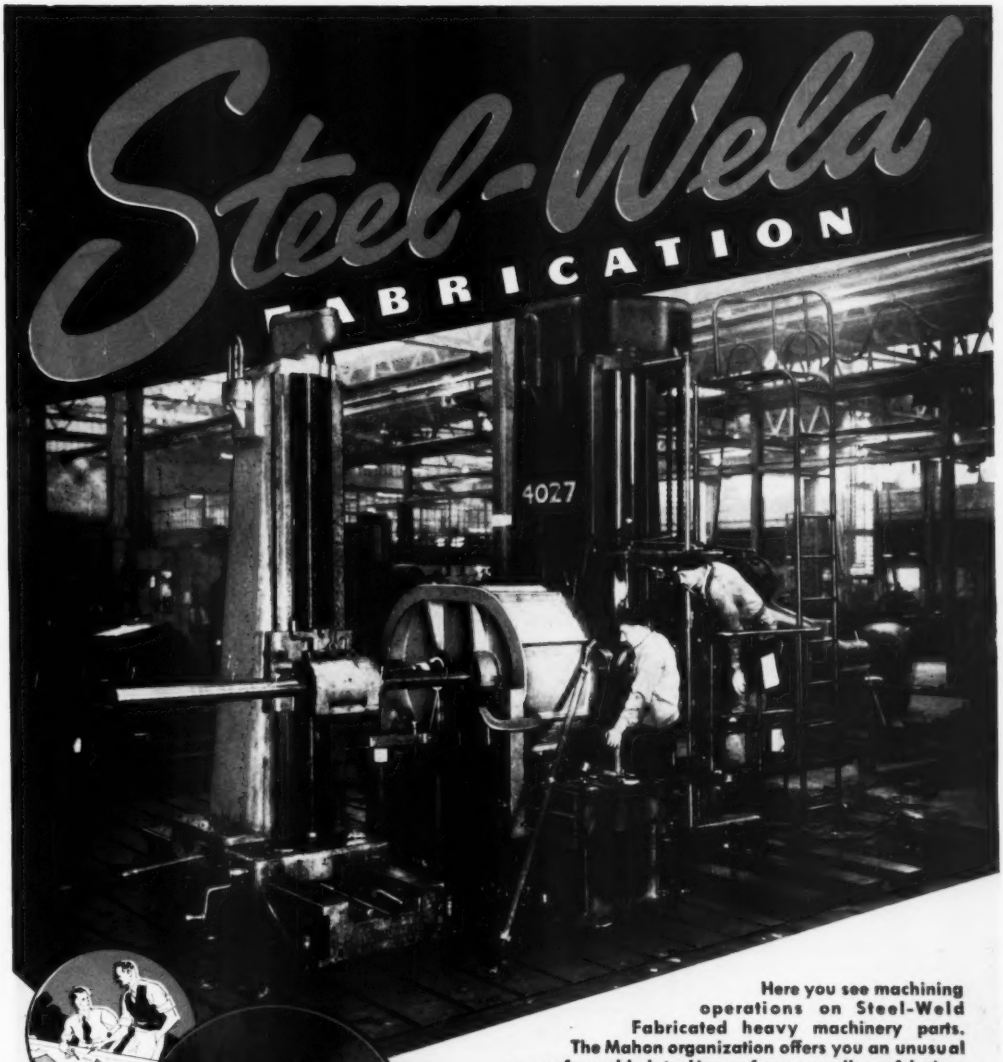
Steel-Weld FABRICATION



Here you see machining operations on Steel-Weld Fabricated heavy machinery parts. The Mahon organization offers you an unusual source for welded steel in any form regardless of design, size, or weight . . . a source with complete facilities for producing, magnetic inspection, stress analysis, normalizing, grit blasting, machining, and spray painting. These facilities, backed by a staff of design engineering experts and highly skilled craftsmen, are your assurance of a better, smoother appearing job, embodying every advantage of Steel-Weld Fabrication.

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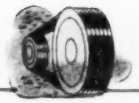
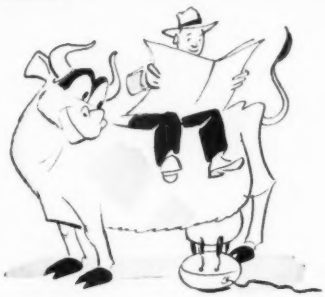
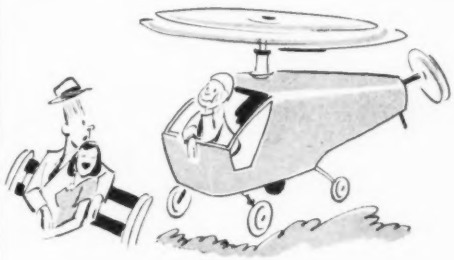


V-Belts can do the darndest things!



MILK A COW. Milking machines use controlled vacuum and gentle fluctuations to get the milk. Most manufacturers use V-Belts to drive the compressor.

WHY V-BELTS? Because they ignore the deteriorating effects of dirt, dust, moisture and animal acids present in every barn. What's more, milking machines must be compact. V-Belt drives permit the use of shorter centers, smaller pulleys. Save weight and space.

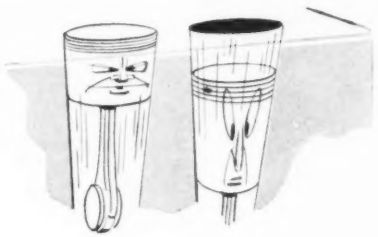


FLY A HELICOPTER. An aviation engineer has recently designed a helicopter that uses V-Belts to transmit the power from the engine to the rotors.

WHY V-BELTS? Because they are one of the most efficient methods of transmitting power known. They won't slip or stall. They are light, long wearing, easy to maintain. And they eliminate shafts, gearing and expensive machining.

SHAKE NUTS FROM A TREE. Raising nuts is big-time business. A leading pecan grower uses a steel cable and an eccentric drive (V-Belt driven) to gently shake the ripened nuts from the trees.

WHY V-BELTS? They absorb shock loads, withstand sudden power. They have a long service life, inexpensive. Operate anywhere with little or no maintenance.



KEEP TOLERANCES TO + or −.0001. When machine tool makers build machines that produce parts held to absolute tolerances, they depend on V-Belt drives to transmit the power.

WHY V-BELTS? Because V-Belts won't vibrate. They start and run smoothly. Absorb the shocks of sudden starts or overload.

WHAT HAVE YOU DONE WITH V-BELTS?

All of the above are drive applications design engineers have told us they have made using Dayton V-Belts. We share them with you in hopes they may help you in your work. We'd like, in turn, your experiences. If you have used V-Belts to solve an unusual problem and think it would help your fellow engineers, write and tell us. We'll be happy to publish it on this page, giving you full credit, of course.

WHAT WOULD YOU LIKE TO DO?

V-Belts have the happy faculty of making drives more efficient, or cheaper, or easier to maintain. Dayton engineers are skilled in how to use them. Dayton builds all kinds of V-Belts, for normal drives, high speeds, shortest possible centers, unusual conditions of heat, oil or static, and the like. They are available in all sizes. Write us your drive problem. We'll be happy to help you solve it. Address *The Dayton Rubber Company, Dayton 1, Ohio.*

Dayton Rubber

THE MARK OF TECHNICAL EXCELLENCE IN NATURAL AND SYNTHETIC RUBBER

SAVE THESE 8 WAYS WITH LAMINUM* SHIMS!

LAMINUM shims are laminated shim brass or steel built into a "solid", unit structure by an exclusive process.

Simply p-e-e-l for your adjustments. No machining, filing or grinding required for accurate factory assembly or service adjustments.

The remaining "solid" shim is always uniform in gauge, with a hard surface . . . clean and smooth as glass.

1. Assembly time reduced up to 30%. No precision machining, grinding, filing, miking.
2. All adjustments made at the job by peeling laminations. No standby lathe.
3. No fumbling and counting loose, paper-thin wafers.
4. Less compressible than ordinary one-piece or stacked shims.
5. Cut to your exact specifications. Less than 1% rejects over the years.
6. Can be fitted with babbitted lugs to prevent oil and pressure loss.
7. No new skill required for use.
8. Your customer recognizes the plus value of less "down time" for maintenance and adjustment.

Send today for chart illustrating 46 money-saving, time-saving applications, detailed specifications, sample of LAMINUM.

PRECISION STAMPINGS in any quantity

Let us quote on your *difficult* stamping jobs. Our experience, tools and presses are geared for *close tolerance* production.

*LAMINUM (Reg. U. S. Pat. Off.) shims are solidly bonded laminations of .002 or .003 inch precision gauge brass or steel with a microscopic layer of metallic binder. Cut to your exact specifications.

LAMINUM
THE SOLID SHIM THAT peels FOR ADJUSTMENT

LAMINATED SHIM COMPANY, Inc.
1405 Union Street Glenbrook, Conn.

SHIMS SHIM STOCK STAMPINGS AN-COR-LOX NUTS

When you need specific information on materials, finishes or parts, reach for your Sweet's File for Product Designers (the big orange file). It contains 169 manufacturers' catalogs full of useful information on thousands of products . . . from absorbers—shock, to zinc. Cross indexing speeds finding.

If Sweet's File for Product Designers is not available in your office, make request immediately for application form. Files are distributed FREE to qualified organizations and individuals.

Sweet's
CATALOG SERVICE
for easier, faster selection of products
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NEW. . . COMPACT Stainless Steel Gate Valve Combines Quality with Economy

COOPER ALLOY
Certified
UNION BONNET
SCREW END
GATE VALVE
FIG. 115

Union bonnet construction for long service life and simplified maintenance.
Minimum of six turns of packing assures effective sealing.
Ball and socket point contact discs adjust themselves in any position.
Back-seating for repacking under pressure.

At last, a compact, completely serviceable, stainless steel gate valve, especially designed by Cooper Alloy engineers to meet the demands of the process industries for an ECONOMICAL corrosion resistant valve that makes no compromise with quality.

Available in various stainless alloys, in sizes ½", ¾" and 1", this Cooper Alloy Certified valve is unusually well suited for fixed plant installations as well as for use on fabricated equipment.

STOCKED BY THESE COOPER ALLOY VALVE DISTRIBUTORS

- Allmetal Screw Prod. Co.
- John B. Astell & Co., Inc.
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- Herman Goldner Co., Inc.
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- Mutual Mfg. & Supply Co.
- Pacific Metals Co., Ltd.
- Horace T. Potts Co.
- Saunders & Company
- Schnitzer Alloy Prod. Co.
- Shawinigan Chm. Ltd.
- Tay-Holbrook, Inc.
- Wiley Alloy Tube Company

Also Available From Leading Stainless Steel Jobbers

The COOPER ALLOY FOUNDRY CO. • Hillside, New Jersey

Bundyweld*... keyed to your tubular needs

Want an open door to faster production, lower costs, higher quality, or better design in your tubular applications?

Latch on to Bundyweld Tubing!*

Bundyweld, made of steel, Monel, or nickel, is double-walled from a single strip, and copper-bonded throughout . . . for extra-strong tubing that's lightweight, ductile and leakproof, too. It can be bent without fear of its weakening or collapsing structurally, and is easily fabricated.

Manufacturers in such diverse fields as television, radiant heating, refrigeration, ranges, tubular toys and automobiles—to mention only a few—have found Bundyweld to be the answer to their tubular needs.

Chances are that this miracle tubing of industry can help solve your manufacturing problem . . . whether design, structural, or functional . . . even though you may not seem to need a tubing at all. Why not give it a try? Contact your near-by Bundy representative among those listed below, or write direct to: *Bundy Tubing Company, Detroit 14, Michigan.*

BUNDY TUBING

ENGINEERED TO YOUR EXPECTATIONS

*REG. U. S. PAT. OFF.

WHY BUNDYWELD IS BETTER TUBING

1 Bundyweld Tubing, made by a patented process, is entirely different from any other tubing. It starts as a single strip of basic metal, coated with a bonding metal.

2 This strip is continuously rolled twice laterally into tubular form. Walls of uniform thickness and concentricity are assured by close-tolerance, cold-rolled strip.

3 Next, a heating process fuses bonding metal to basic metal. Cooled, the double walls have become a strong ductile tube, free from scale, held to close dimensions.

4 Bundyweld comes in standard sizes, up to ⅝" O.D., in steel (copper or tin coated), Monel or nickel. For tubing of other sizes or metals, call or write Bundy.

BUNDY TUBING DISTRIBUTORS AND REPRESENTATIVES

Cambridge 42, Mass.: Austin-Hastings Co., Inc., 226 Binney St. • ***Chattanooga 2, Tenn.***: Peirson-Deakins Co., 823-824 Chattanooga Bank Bldg. ***Chicago 32, Ill.***: Lapham-Hickey Co., 3333 W. 47th Place • ***Elizabeth, New Jersey***: A. B. Murray Co., Inc., Post Office Box 476 • ***Philadelphia 3, Penn.***: Rutan & Co., 404 Architects Bldg. • ***San Francisco 10, Calif.***: Pacific Metals Co., Ltd., 3100 19th St. • ***Seattle 4, Wash.***: Eagle Metals Co., 3628 E. Marginal Way • ***Toronto 5, Ontario, Canada***: Alloy Metal Sales, Ltd., 881 Bay St.

BUNDYWELD NICKEL AND MONEL TUBING IS SOLD BY INTERNATIONAL NICKEL COMPANY DISTRIBUTORS IN PRINCIPAL CITIES.

THIS WIDE RANGE OF PUMPS MAKES SELECTION EASIER

COOLANT PUMPS
Centrifugal
Geared

LUBRICATING PUMPS
Geared
Vane

HYDRAULIC PUMPS
Geared

MISC. MACHINE PUMPS
Centrifugal
Geared
Vane

DIRECT DRIVE OR MOTOR DRIVEN

The wide variety of types and sizes available in Brown & Sharpe Pumps simplifies your selection of the right pump for the job.

Every pump in this line has distinctive features to assure economical, dependable long-life service. All have the same familiar standards of high quality that characterize Brown & Sharpe machine and tool equipment.

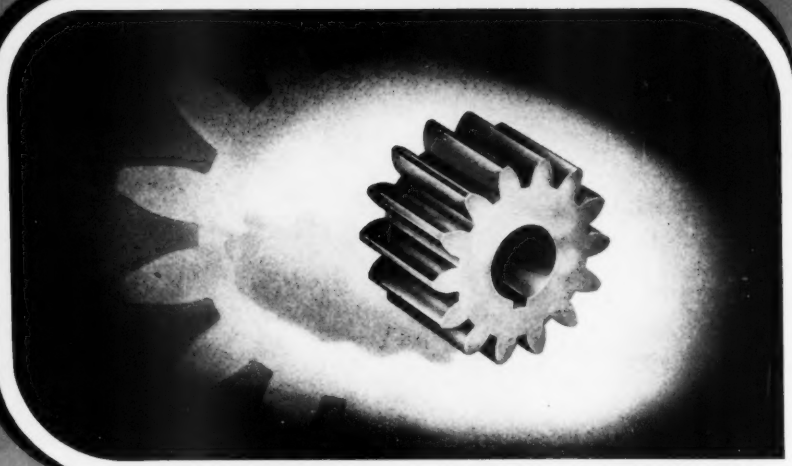
Make your selection with the help of our latest pump catalog. It includes illustrations, complete descriptions, installation dimensions and charts showing performance characteristics. Brown & Sharpe Mfg. Co., Providence 1, R. I., U.S.A.

We urge buying through the Distributor

BROWN & SHARPE PUMPS

ASK STOKES

Saving 53% on This Part!



IT'S MADE from powder metal!

Powder metal is best for many things and this pinion gear is one of them.

It staggers the imagination to think how many of these pinion gears in iron or brass are turned out annually . . . and what savings could be made in machining, inspection and cutting-waste if all were done in powder metal!

The gear is shown in exact size in the picture above. Tolerances are within .002" O.D. and .0005" I.D. The gear can be made without keyway if desired . . . or with holes in it . . . or with teeth for only part of the circumference . . . or only part of the width. It can have a non-metal part bonded to it . . . or a shaft instead of a hole.

One is tempted to say there is no limit to what can be done by the powder metal process . . . but there is! Size of part, quantity, and design determine the suitability of powder metal for a part.

Stokes does not make powder metal parts . . . we make the equipment for producing them. We shall be pleased to advise on the suitability of this process for your needs. Send us your blueprints or sample parts.

F. J. Stokes Machine Company,
5900 Tabor Rd., Phila. 20., Pa.

FJS

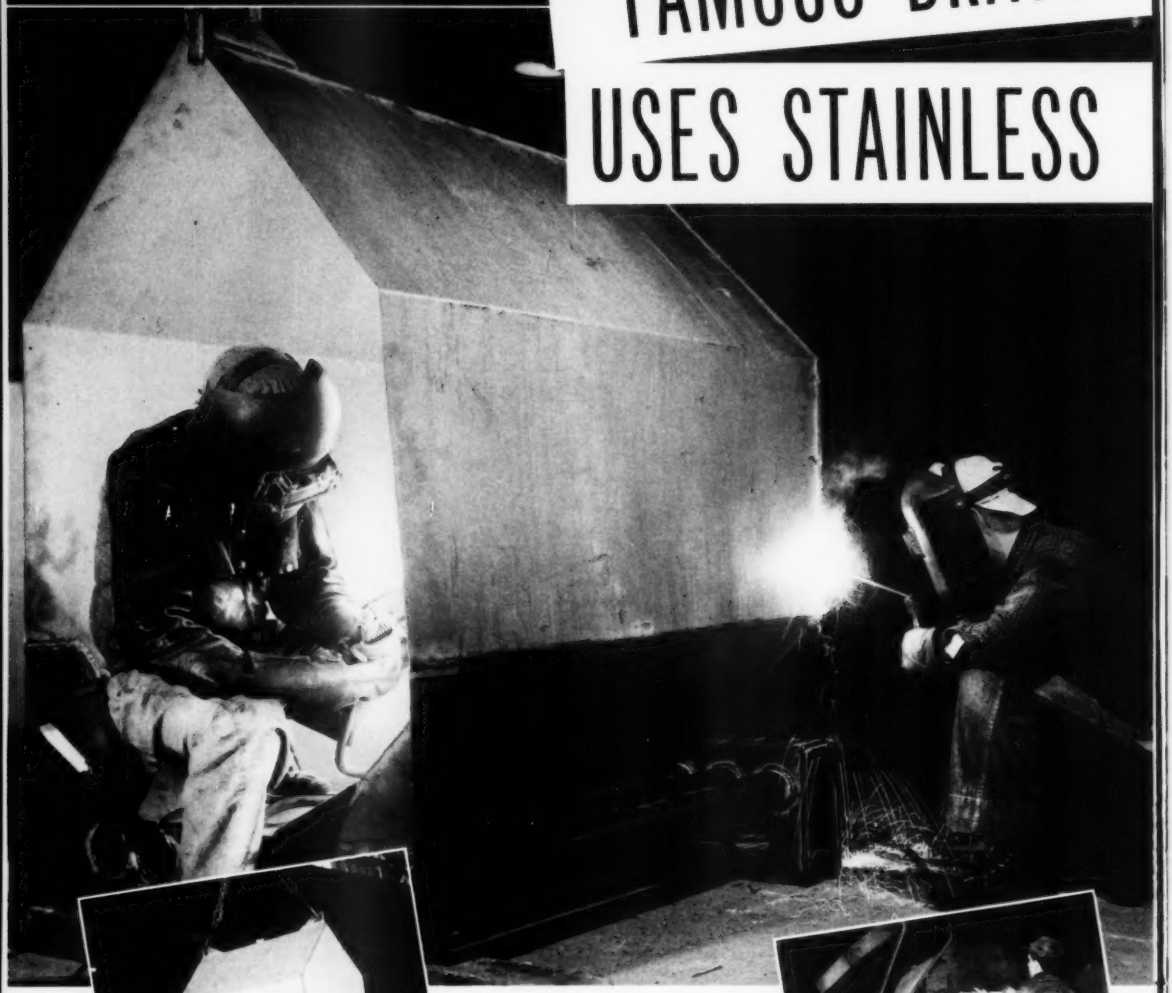
Stokes makes Semi-Automatic and Automatic Molding Presses, Plunger Presses, Closure Presses, Preforming Presses, Industrial Tabletting and Powder Metal Presses, Vacuum and Special Processing equipment, Water Stills and Special Machinery.

STOKES KNOWS HOW

Quantity
PRODUCTION
of
GREY IRON CASTINGS
ONE OF THE NATION'S
LARGEST AND MOST MODERN
PRODUCTION FOUNDRIES
ESTABLISHED 1866
THE WHELAND COMPANY
FOUNDRY DIVISION
MAIN OFFICE AND MANUFACTURING PLANTS
CHATTANOOGA 2, TENNESSEE

Who said it costs more to use Stainless Steel?

FAMOUS DRAVO USES STAINLESS

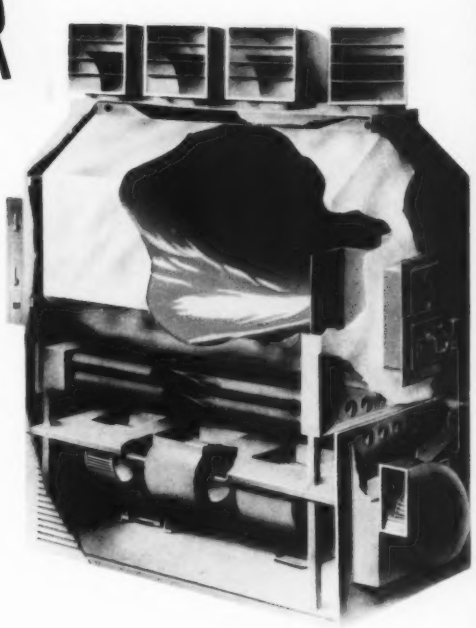


(Above) The Stainless Steel combustion chamber —the "heart of the heater"—takes finished shape. Note the simplicity of construction. Outer seams are continuous-welded, inside seams are intermittent. *(At left)* The completed Stainless chamber goes into the frame as a unit.

(At right) Outer casting goes on. Fastened with sheet metal screws, panels can be easily and quickly removed. Asbestos gaskets make joints air-tight. Mass production methods insure uniform, speedy manufacture.

Counterflo HEATER

TO REDUCE COSTS!



Completely self-contained, automatic in operation, this direct-fired heater provides an entirely new solution to the troublesome problem of plant heating. A "single-package" heating unit that can be positioned anywhere, it supplies heat directly to the area needing it, efficiently and economically.

Incidentally, it also proves that using Stainless Steel does not necessarily increase cost, but on the contrary, can decrease it.

THE heart of any heater is the combustion chamber. In the original Dravo Heater sold by the thousands to army camps and plants during the war, this chamber was made of corrugated carbon steel lined with refractory cement. Numerous fins and deflectors were welded to its outer surface.

To meet the tremendous civilian demand created by its highly successful war-time service, Dravo engineers recently redesigned the heater to increase its efficiency, to reduce its size and weight, to increase its life span, to make its operation safer. And in order to maintain prices in the face of rising labor and material costs, they took steps to speed up its production and to reduce manufacturing costs. They accomplished these things mainly by building the combustion chamber of Stainless Steel.

By specifying Stainless Steel that withstands temperatures up to 1600°F. they got rid of the troublesome and maintenance-demanding refractory lining. The unlined chamber, with its entire surface now exposed to the flame and gases, greatly increased heat transfer. This made it possible to eliminate fins and deflectors, allowed them to build the chamber smaller (to reduce its heating surface 53% without reducing operational performance) . . . and to reduce its weight 1500 pounds.

In addition, the simplified chamber design obtained by the use of Stainless Steel reduced the number of fabricating operations from 95 to 67. And, even though welding with Stainless requires more care, welding costs too were reduced because only 186 lineal feet of welding were required instead of 400 feet.

• To indicate how U·S·S Stainless Steel might benefit *you* in similar constructions, we recapitulate the benefits Dravo has obtained by using Stainless:—It has enabled them to employ less expensive manufacturing procedures than those used previously. It has insured greater portability for their equipment. It has improved heat transfer and eliminated expensive refractory maintenance. Dravo is now sold on the use of Stainless Steel because, as their engineers report, it has given them a tremendous advantage over competition in many respects, one of the most important being *lower cost of manufacture.*

AMERICAN STEEL & WIRE COMPANY, GENERAL OFFICES: CLEVELAND, OHIO
CARNEGIE-ILLINOIS STEEL CORPORATION, PITTSBURGH & CHICAGO
COLUMBIA STEEL COMPANY, SAN FRANCISCO · NATIONAL TUBE COMPANY, PITTSBURGH
TENNESSEE COAL, IRON & RAILROAD COMPANY, BIRMINGHAM
UNITED STATES STEEL SUPPLY COMPANY, WAREHOUSE DISTRIBUTORS, COAST-TO-COAST
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

U·S·S STAINLESS STEEL

SHEETS · STRIP · PLATES · BARS · BILLETS
PIPE · TUBES · WIRE · SPECIAL SECTIONS

United States Steel Corporation Subsidiaries
Room 2069 Carnegie Building, Pittsburgh 30, Pa.

☐ Please send me the new book, "An Introduction to U·S·S Stainless Steel."

☐ Please have a Stainless representative call on me.

Name.....

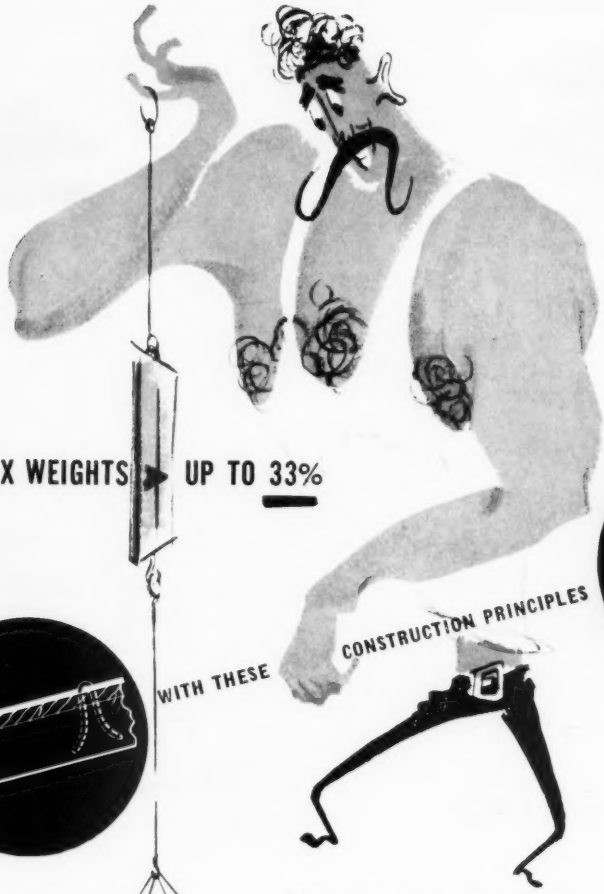
Position.....

Company.....

Address.....

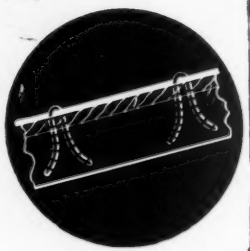
City..... Zone.... State.....

UNITED STATES STEEL



REDUCE BOX WEIGHTS ▶ UP TO 33%

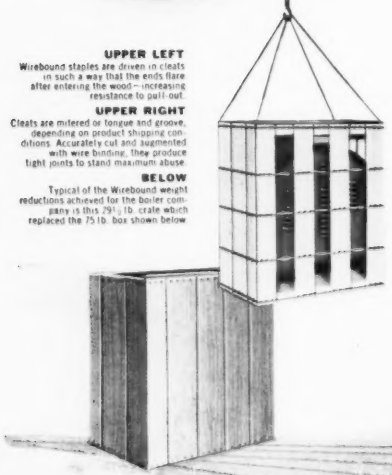
WITH THESE CONSTRUCTION PRINCIPLES



UPPER LEFT
Wirebound staples are driven in cleats in such a way that the ends flare after entering the wood—increasing resistance to pull-out.

UPPER RIGHT
Cleats are mitered or tongue and groove, depending on product shipping conditions. Accurately cut and augmented with wire binding, they produce tight joints to stand maximum abuse.

BELOW
Typical of the Wirebound weight reductions achieved for the boiler company is this 29½ lb. crate which replaced the 75 lb. box shown below.



Like so many other manufacturers, a well known manufacturer of heating equipment* found that Wirebound Boxes and Crates brought savings obtainable with no other shipping container! Box weights were reduced 33⅓; over-all shipping room savings were 25%; storage requirements were slashed 80%; container assembly and packing time were cut 50%.

Wirebound's unique construction principles will enable you to obtain similar benefits. Specifically designed for the product it is to carry, each Wirebound is composed of high tensile steel wires stitched to thinner wood for face material. Thickness of boards, arrangement of reinforcing battens and number and gauge of wires vary in accordance with the type and weight of contents.

This is only part of the Wirebound story . . . to learn all the advantages of Wireboards use the coupon at right to request a copy of the free Technical Data Book or have a Wirebound sales engineer call to study your problems.

WIREBOUND BOX MFRS. ASS'N.
Room 1820, Borland Bldg., Chicago 3, Illinois

☐ SEND COMPLETE LITERATURE
☐ SEND A SALES ENGINEER

NAME
POSITION
FIRM NAME
ADDRESS
CITY ZONE STATE
PRODUCT

Wirebound BOXES & CRATES

60 WIREBOUND PLANTS THROUGHOUT THE UNITED STATES

*Name on request

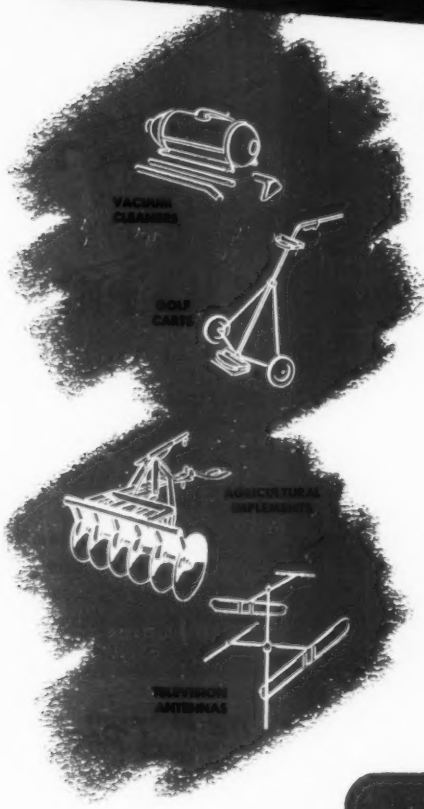
NOW *is the time to* REDESIGN

...with

ELECTRUNITE

MECHANICAL TUBING

...HOT OR COLD ROLLED STEEL



Improved appearance . . . lighter weight . . . added rigidity . . . greater strength . . . lower fabricating costs . . . these are but a few of the reasons why you should seriously consider tubing in redesigning today's products for tomorrow's markets.

In many cases, particularly with Republic ELECTRUNITE Tubing, simplified fabricating procedures alone will result in effective production savings. As manufactured by Republic's electric resistance welding process, ELECTRUNITE Tubing is unsurpassed for uniformly high ductility, surface quality, strength and accuracy of section. This modern tubing takes all forms of plated and painted finishes readily and economically.

For tubing users who do not possess complete fabricating facilities, Republic offers semi- or full-fabricated tubular parts from its large, modern fabricating plant centrally located in Ferndale, Michigan.

Complete information about ELECTRUNITE Tubing and the process by which it is made, as well as helpful technical assistance with your specific tubing problems, is available upon request. Write today to:

REPUBLIC STEEL CORPORATION
STEEL AND TUBES DIVISION • CLEVELAND 8, OHIO
Export Department: Chrysler Building, New York 17, New York

REPUBLIC STEEL

Republic
ELECTRUNITE TUBING

The Fasteners that add *EXTRA*ordinary strength to your product *EXTRA*ordinary speed to its assembly---

Kaufman Cold-Forging Processed

Cleveland High Carbon Heat Treated Cap Screws

● The extra toughness of Cleveland High Carbon Heat Treated Cap Screws adds greater safety to your product; extra precision forming speeds assembly, minimizes rejects. These extra values to you are the result of the Kaufman Double Extrusion Process of cold forging—a method that assures you stronger threaded fasteners than any other known process. It pays you to specify and buy Cleveland High Carbon Heat Treated Cap Screws. The Cleveland Cap Screw Co., 2917 East 79th St., Cleveland 4, Ohio; Warehouses, Chicago and Philadelphia.

CLEVELAND *Top Quality* **FASTENERS**

ORIGINATORS OF THE KAUFMAN DOUBLE EXTRUSION PROCESS

Specialists for more than 30 years in

CAP SCREWS, SET SCREWS, MILLED STUDS

Ask your jobber for Cleveland Fasteners

PAGE

Stainless Steel WIRE

ROUND

FLAT

OR

SHAPED

PAGE has been drawing stainless steel wire since the earliest development of stainless — for many manufacturers has become "Wire Headquarters."

Think of PAGE as a responsible source for wire — stainless steel, high or low carbon steel. Whatever your problem involving wire . . .

Get in touch with Page!

ACCO

Monessen, Pa., Atlanta, Chicago, Denver, Detroit, Los Angeles, New York, Pittsburgh, Philadelphia, Portland, San Francisco, Bridgeport, Conn.

PAGE STEEL AND WIRE DIVISION
AMERICAN CHAIN & CABLE

when they're NICE

They're RIGHT for the job!

FROM high quality, close tolerance "ground all over" Precision Ball Bearings. . . . .

TO low cost "unground" Ball Bearings of inexpensive design and construction.

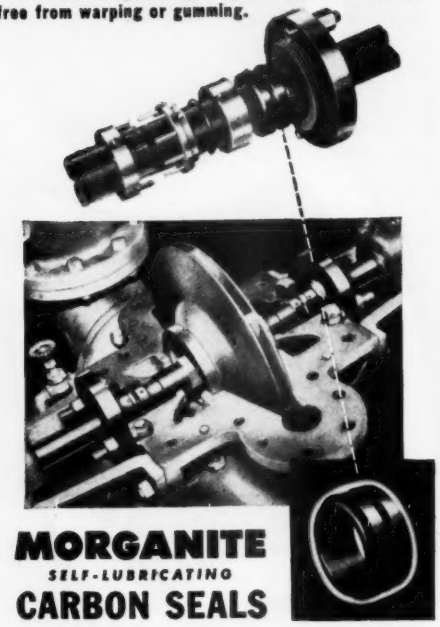
Have you any Ball Bearing requirements on which we may quote? For complete information on the Nice Line write for Catalog No. 125.

NICE

NICE BALL BEARING COMPANY
NICETOWN · PHILADELPHIA · PENNSYLVANIA

PROBLEM: To produce a mechanical seal capable of withstanding corrosive chemicals . . . grit . . . high shaft speeds . . . highly volatile fluids . . . under extreme pressures.

SOLUTION: Morganite self-lubricating seals . . . immune to chemical attack . . . grit . . . abrasives . . . mechanically strong . . . provide perfect sealing free from warping or gumming.



MORGANITE
SELF-LUBRICATING
CARBON SEALS

In continuous service where pressures and shaft speeds are extremely high, Morganite Seals have proven highly efficient. They are recommended for use in pumps, agitators, mixers and similar equipment handling liquids including corrosives. Where maintenance is difficult due to inaccessibility, the self-lubricating feature is especially valuable. Costly repairs and lengthly shut downs due to seal failures are eliminated.

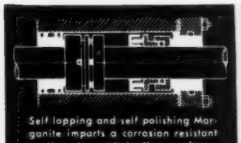
See our CATALOG in SWEET'S FILE for Product Designers

Additional data on Morganite will be found in Sweet's File for Product Designers. For competent engineering help on specific problems consult a Morganite sales engineer. There is no obligation.

REGISTERED TRADE MARK

Morganite INCORPORATED

LONG ISLAND CITY 1, NEW YORK



Self lapping and self polishing Morganite imparts a corrosion resistant coating to participating surfaces.

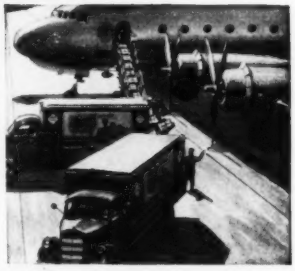
Seal units incorporating Morganite are available with self-adjusting and wear-compensating features.

Manufacturers of Morganite Carbon Brushes for all motor and generator applications, and Morganite Carbon Piles.

$5.07 saved a contract . . . and a man's business

Special switches were needed to complete an electrical instrument contract. Late delivery of finished items would kill chances of future orders. Switches were **1100** miles away, but Air Express delivered the 13-lb. package 8 hours after pick-up. Cost, only **$5.07**. Air Express now used regularly. Keeps down inventory, improves customer service.

Low as $5.07 was, remember Air Express rate *included* door-to-door service, receipt for shipment and more protection. It's the world's fastest shipping service that *every* business uses with profit.



World's finest Scheduled Airline fleet carries Air Express. 24-hour service—speeds up to 5 miles a minute. Direct to over 1000 airport cities; air-rail for 22,000 off-airline offices.

Facts on low Air Express rates

17-lb carton of hearing aids goes **900** miles for **$4.70.**
12 lbs. of table delicacies goes **600** miles for **$2.53.**
(Same day delivery in both cases if you *ship early.*)

Only Air Express gives you all these advantages: Special pick-up and delivery *at no extra cost. You get a receipt for every shipment* and delivery is proved by signature of consignee. One-carrier responsibility. Assured protection, too—valuation coverage up to $50 without extra charge. Practically no limitation on size or weight. For fast shipping action, phone Air Express Division, Railway Express Agency. And specify "Air Express delivery" on orders.

SPECIFY AIR EXPRESS
AIR EXPRESS GETS THERE FIRST

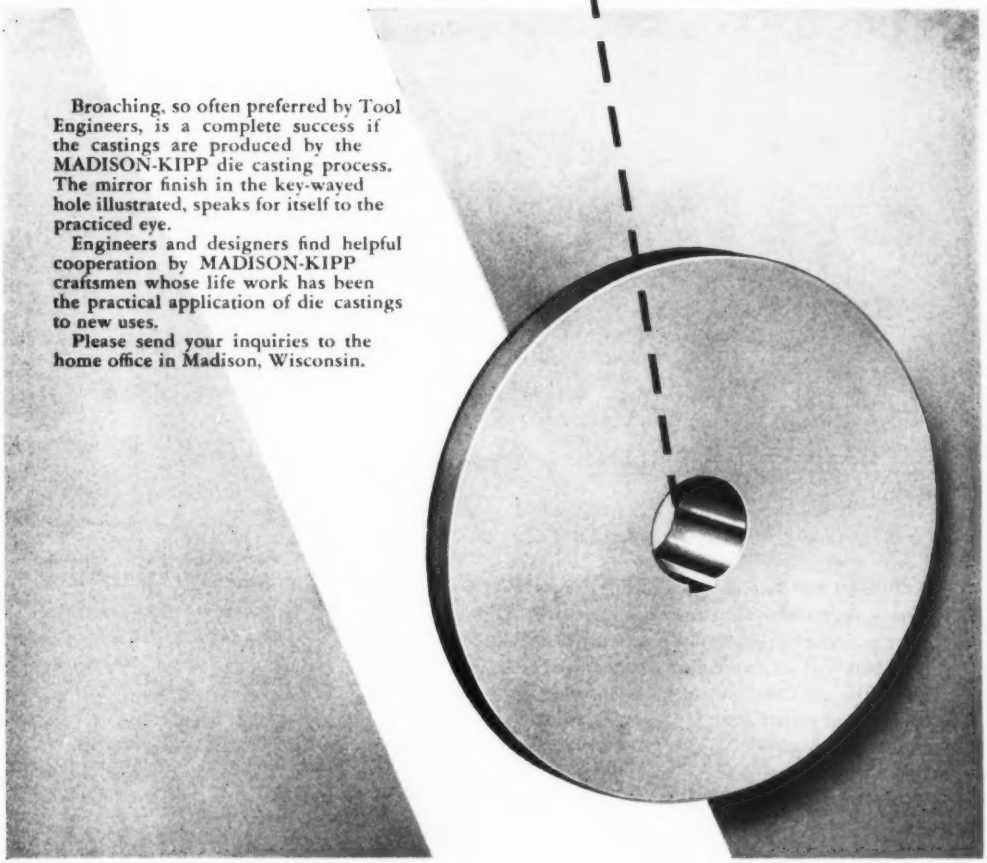
Rates include pick-up and delivery door to door in all principal towns and cities

AIR EXPRESS, A SERVICE OF RAILWAY EXPRESS AGENCY AND THE
SCHEDULED AIRLINES OF THE U.S.

EXCELLENT BROACHING RESULTS

with the

MADISON-KIPP *dense zinc die castings*



Broaching, so often preferred by Tool Engineers, is a complete success if the castings are produced by the MADISON-KIPP die casting process. The mirror finish in the key-wayed hole illustrated, speaks for itself to the practiced eye.

Engineers and designers find helpful cooperation by MADISON-KIPP craftsmen whose life work has been the practical application of die castings to new uses.

Please send your inquiries to the home office in Madison, Wisconsin.

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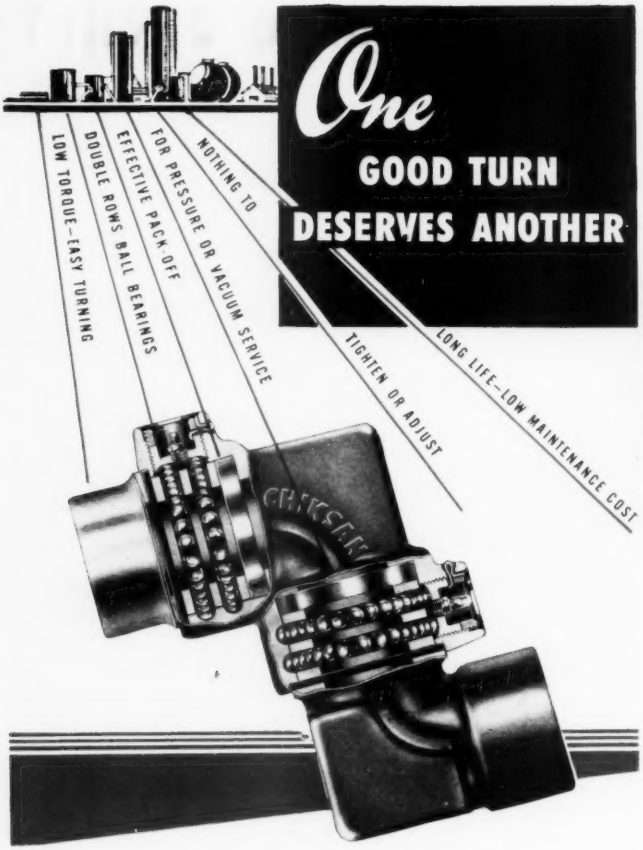

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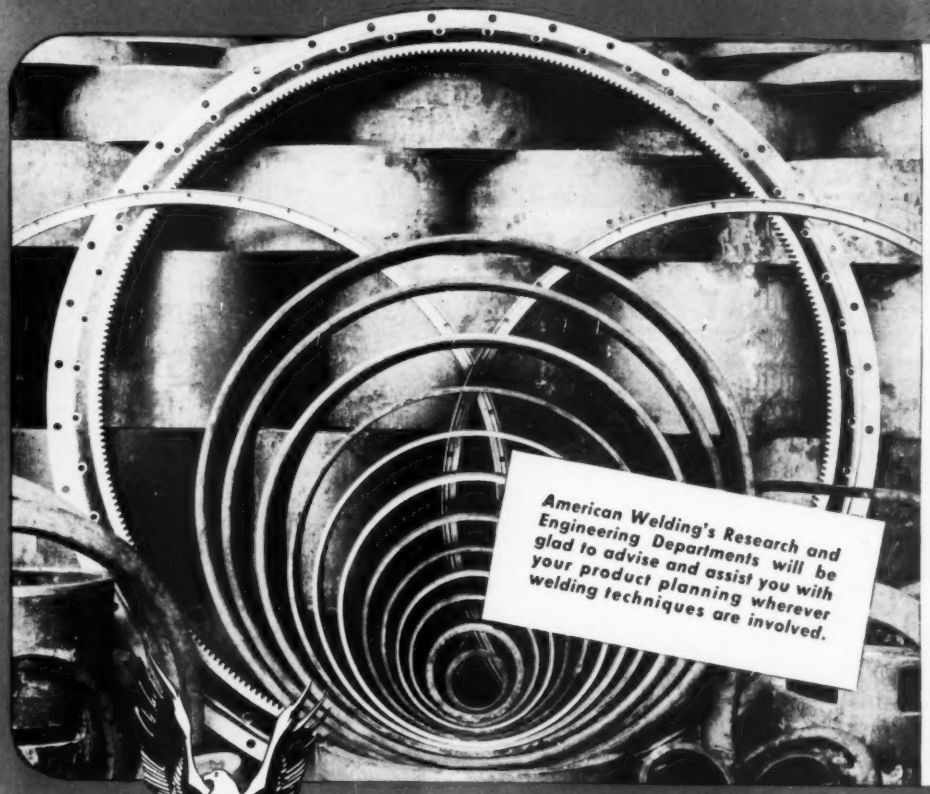

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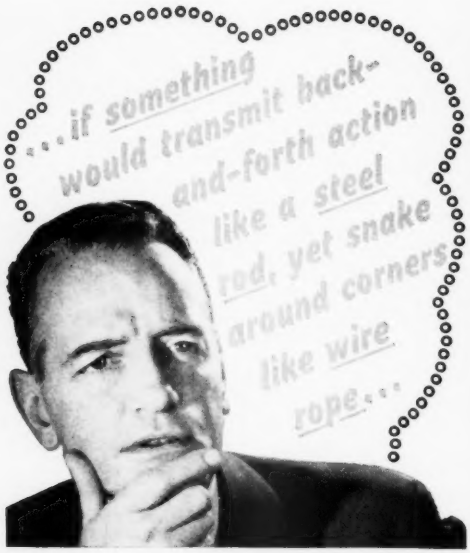

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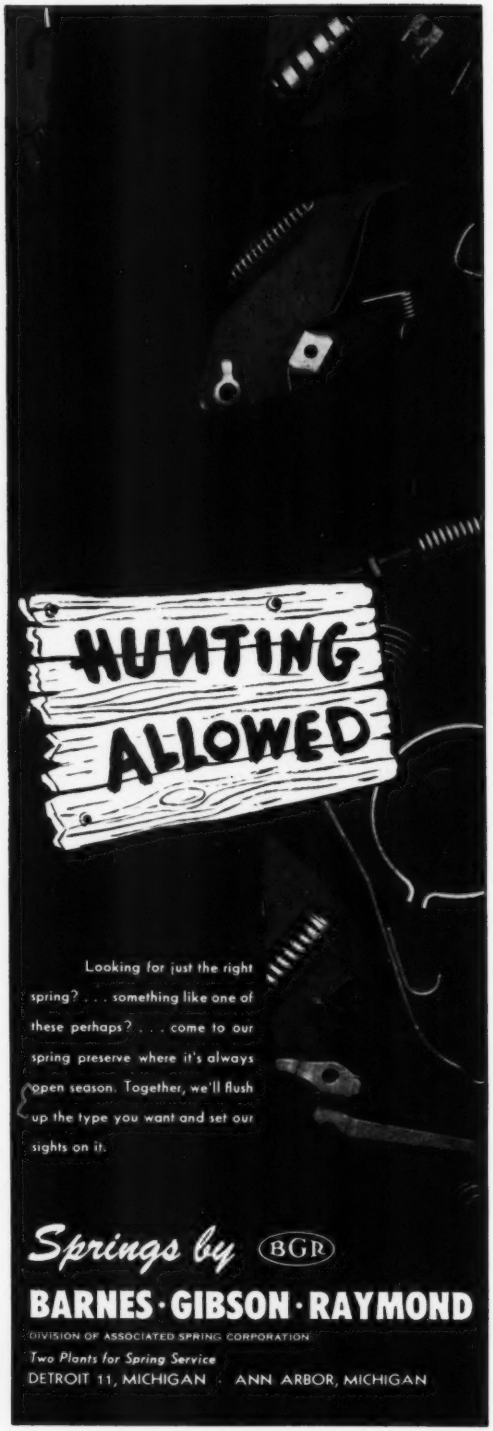

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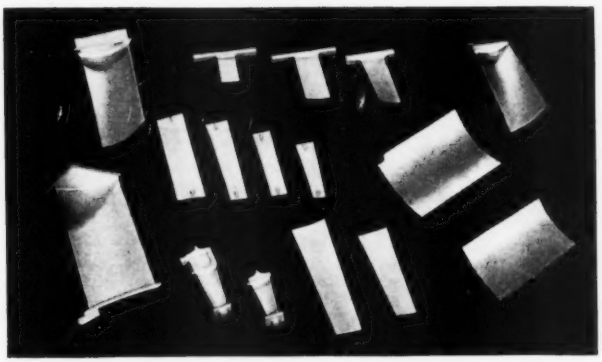

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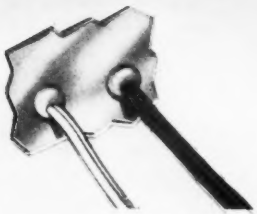

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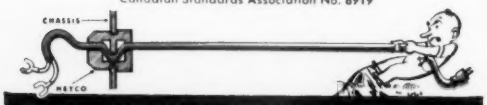

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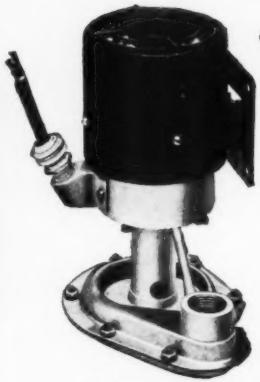

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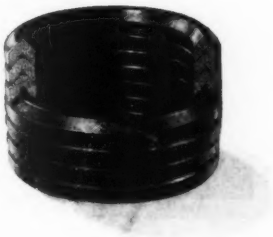

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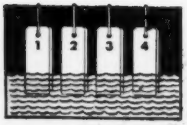

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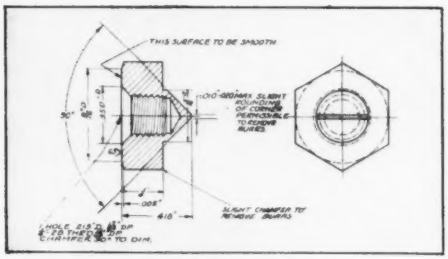
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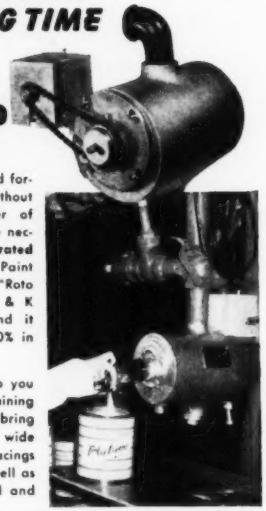

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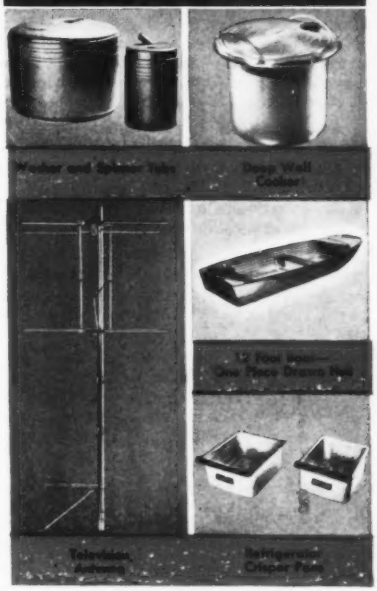

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C-646	Std.	1"	3-1/8"	2500	5150
CS-46	Ball	1"	3-1/8"	1250	3600
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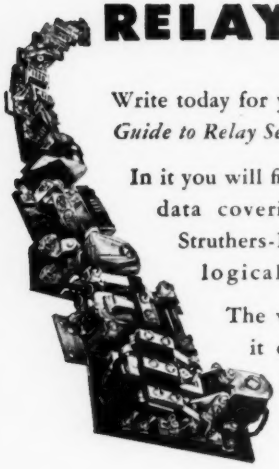

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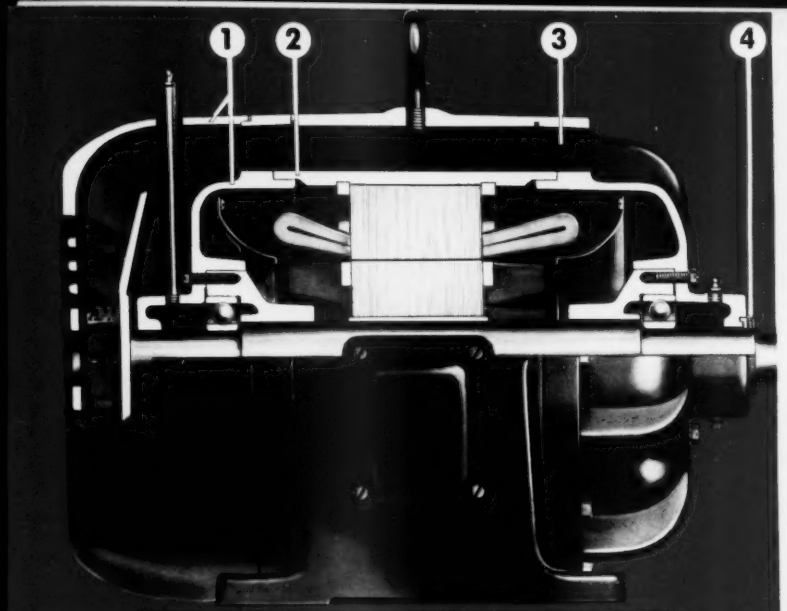

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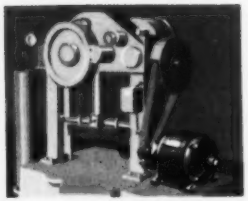
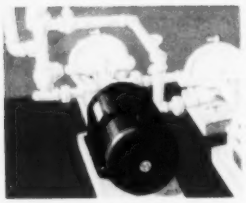


G-E open (dripproof) induction motors for constant-load, constant-speed applications. From 1 to 2000 hp.



G-E totally enclosed motors for outdoor operation, in abrasive dusts, or corrosive fumes. From 1 to 1000 hp.

G-E gear-motors for low-speed operation. A normal-speed motor with built-in reduction gear. From ⅛ to 75 hp.

G-E synchronous motors for maintaining exact speeds or for correcting power factor. From 20 to 1000 hp.

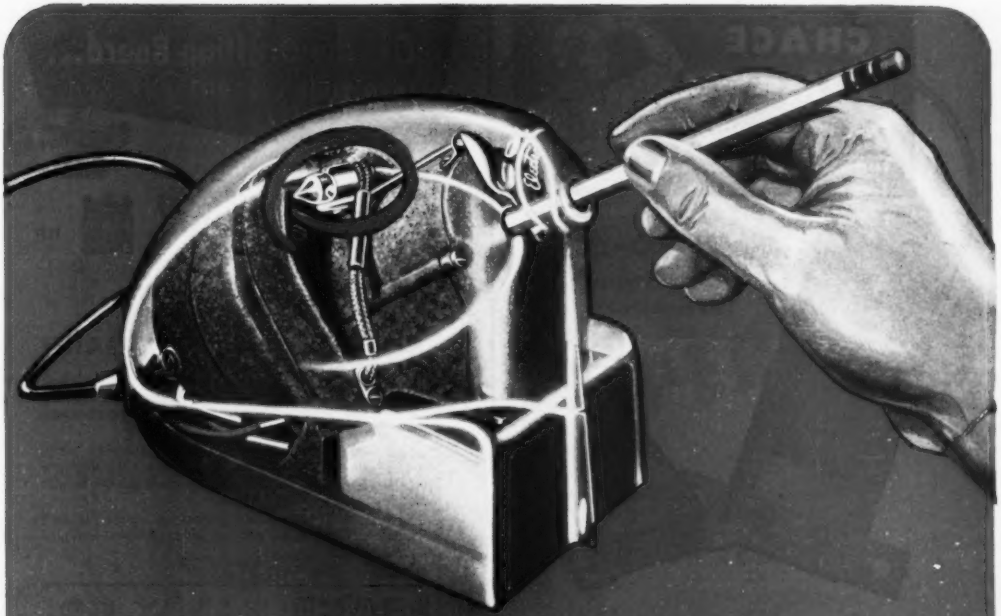
YOU CAN'T BEAT

TRI CLAD

EXTRA PROTECTION

GENERAL ELECTRIC

760-9



POSITIVE ACTION *every time!*

SIMPLE, dependable operation, time after time after time, is a *must* with this Electro-Pointer pencil sharpener. And, in spite of dust and shavings, the Honeywell Mercury Switch provides dependable on-off contact . . . *positive action every time!*

This application may suggest a way in which you can cut costs and improve performance of *your* product. Honeywell Mercury Switches are tiny and compact . . . are adaptable to unusual mountings. They operate at low angles . . . have no moving parts . . . are sealed against dust, gas and corrosion.

Honeywell Mercury Switches give you greater latitude in product design . . . improve performance and operating efficiency. Send for Catalog 1343 for more detailed information.

WITH THE

HONEYWELL MERCURY *Switch*

MINNEAPOLIS-HONEYWELL REGULATOR CO.
BROWN INSTRUMENTS DIVISION
4459 Wayne Ave., Philadelphia 44, Pa.
Offices in principal cities of the United States, Canada and throughout the world

WHEN YOU WANT

- **POSITIVE ACTION**
- **CONTACT CAPACITY**
- **LONGER LIFE**
- **WIDE SELECTION**

SPECIFY THE HONEYWELL MERCURY *Switch*

MINNEAPOLIS **Honeywell**

Mercury Switches
FOR POSITIVE ACTION

BROWN INSTRUMENTS

No. 27—Product of
THERM-O-DISC, Inc., Mansfield, Ohio

Chace Thermostatic Bimetal, due to its dependability, was selected for this water heater thermostat, manufactured by Therm-O-Disc, Incorporated, Mansfield, Ohio.

The actuating element is a strip of Chace No. 2400 Thermostatic Bimetal. Fatigue tests were made of over 200,000 operating cycles, which were far more severe than actual operation requires, and at the end of these tests no change had occurred in the accuracy of the control.

Chace No. 2400 is a general purpose bimetal for applications from −100° to 600° F. Its characteristics include high deflection rate and torque, and it can be used up to 1000° F.

Chace No. 2400 is just one of many bimetals developed for actuating elements in temperature indication or control devices; all are available in strips or finished pieces. Submit your problems in this field to the Engineering Department of the W. M. Chace Company for their recommendations.

W. M. CHACE CO.
Manufacturers of Thermostatic Bimetals
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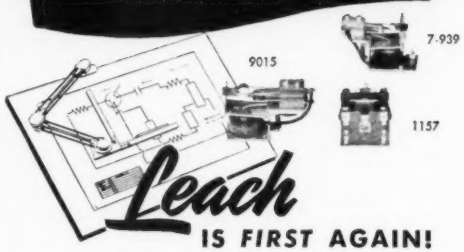
Off the Drafting Board...
INTO YOUR CIRCUIT!



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Leach is *first* again with newly modified *Relays* designed, engineered and constructed to meet *your* specific requirements. For easier installation, better performance and longer life.

No. 7-939 is a newly modified motor starting relay. No. 1157 is an industrial type for handling 12½ amperes. No. 9015 is a motor starting relay designed to handle motor loads up to 3 horsepower.

Highest standards of engineering, materials and workmanship. *For better controls through better relays*—CONTACT LEACH.

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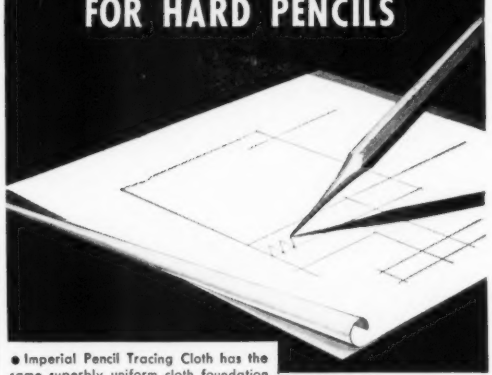

● Imperial Pencil Tracing Cloth has the same superbly uniform cloth foundation and transparency as the world famous Imperial Tracing Cloth. But it is distinguished by its special dull drawing surface, on which hard pencils can be used, giving clean, sharp, opaque, non-smudging lines.

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Users of aluminum castings have learned it pays to use "Castings by Permite." Their greater tensile strength, close tolerances, consistent uniformity help metalworking manufacturers speed production and save on parts and labor costs. Aluminum castings that will best serve your specific needs are assured by Permite's unexcelled facilities for producing permanent mold, sand and die castings. Submit your parts requirements to Permite for prompt recommendations and quotations.

ASK FOR NEW 80-PAGE CASTING MANUAL

Authoritative illustrated manual on the design, production and uses of aluminum castings. Includes casting alloys tables. Sent free on request to interested executives.

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ALUMINUM INDUSTRIES, INC.

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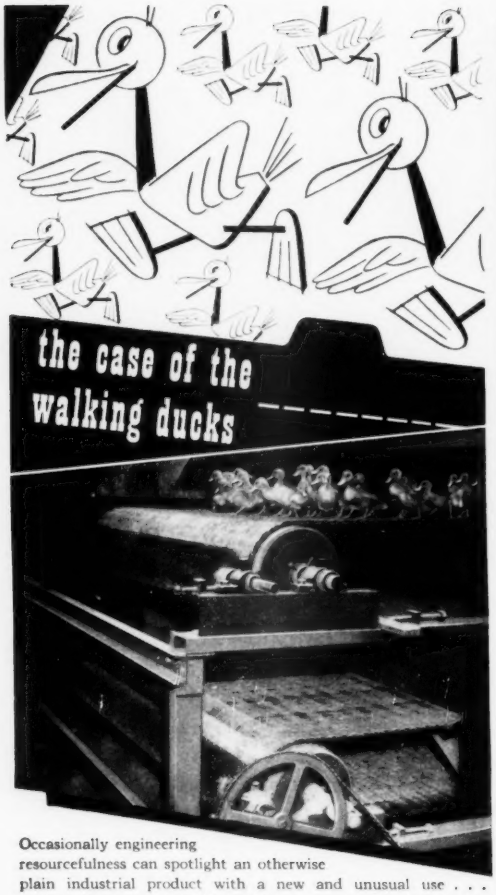
ALUMINUM PERMANENT MOLD, SAND and DIE CASTINGS...HARDENED, GROUND and FORGED STEEL PARTS



Occasionally engineering resourcefulness can spotlight an otherwise plain industrial product with a new and unusual use . . . such as the case of this Woven Wire Conveyor Belt installation in a duck brooder.

Newly hatched ducklings, it seems, have to be kept moving to be kept alive. Placed on this specially built woven wire belt moving at a slow rate of speed, the ducklings remain there for eight days . . . continually treadmilling away from the falling end of the belt. Mortality rate dropped to zero. By-product recovery . . . duck droppings for fertilizer . . . is aided by the open mesh of the woven wire belt.

Even if you don't operate a duck hatchery, call in a Cambridge engineer whenever you have a problem concerning the movement of materials or products during processing. Let him explain the superior construction features of . . .

CAMBRIDGE Woven Wire Conveyor Belts

This illustrated 130 page catalog—FREE—to men concerned with production control. WRITE TODAY.

Cambridge Wire Cloth Co.

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FINE FORGINGS

is . . . KNOWLEDGE and EXPERIENCE. Since 1866, MERRILL BROTHERS' ingenuity and forging "know how" has solved thousands of product problems for industry.

Hard-to-get-jobs become simple the MERRILL way—and these fine forgings cut costs, improve product quality and appearance.

The illustration is a MERRILL Product made for Castle Key Corporation, New York City, N.Y. Another intricate problem solved by Merrill 'knowhow'.

MERRILL
BROTHERS

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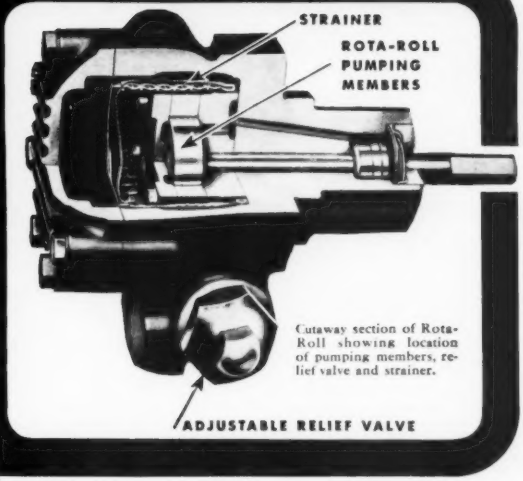
Producers of the MERRILL volz Lifting Clamp

Improve Your Product Without Increasing Cost...

With This Low Pressure, Low Cost Pumping Unit

It's small, compact and ideal for applications such as engine lubrication, compressor bearing lubrication, small capacity oil transfer, barber and dental chairs, small cylinder actuation and many others.



Cutaway section of Rota-Roll showing location of pumping members, relief valve and strainer.

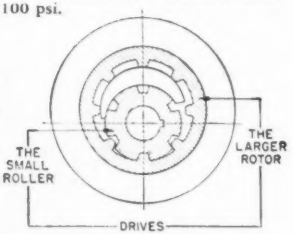
Complete With Pump, Relief Valve and Strainer

The Sundstrand Rota-Roll is more than a pump. It's a *pumping unit* complete with pump, relief valve and strainer. It's produced in large quantities on high production machinery—making its cost less than the cost of most pumps alone.

Available in 6 Sizes: From 11 G.P.H. to 40 G.P.H.

This pump has an adjustable relief valve which can be furnished in any of four pressure ranges of 20 to 40 psi, 40 to 80 psi, 80 to 150 psi, or 150 to 300 psi. The six capacities available range from 11 gph to 40 gph. These figures are based on a motor speed of 1725 rpm and 100 psi.

Check These 6 Advantages



1 ROTA-ROLL PRINCIPLE of pumping members promotes quiet operation, longer life because (see sketch) smaller roller is keyed to shaft and drives outer member at a speed 25% lower than motor speed.

2 QUIET OPERATION because ROTA-ROLL pumping members and efficient inlet port design reduces cavitation at the inlet port.

3 SMOOTH UNIFORM FLOW AT ALL PRESSURES because rotating roller and rotor are self-emptying, eliminating turbulence, and other interference with smooth, uniform flow of oil.

4 SMALL AND COMPACT (see illustration) will lend itself to and improve your product appearance.

5 HIGH OVERALL EFFICIENCY at maximum continuous duty pressure.

6 LOW COST OF THE ROTA-ROLL pumping unit is achieved through mass production manufacturing.

GET COMPLETE DATA FREE

Look into all of the features of this outstanding pumping unit. Complete description and mounting dimensions included. Ask for bulletin No. P-41.

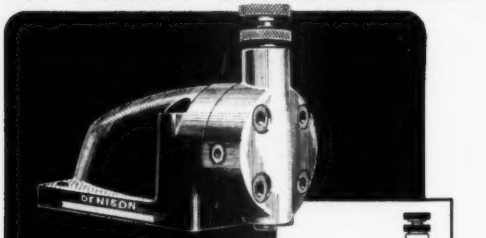
SUNDSTRAND MACHINE TOOL CO. • ROCKFORD, ILLINOIS, U.S.A.

SUNDSTRAND HYDRAULIC DIVISION

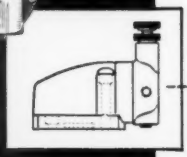
2560 ELEVENTH STREET • ROCKFORD, ILLINOIS

FUEL UNITS • HYDRAULIC PUMPS • TRANSMISSIONS • FLUID MOTORS • VALVES and CONTROLS

Really Quiet
HYDRAULIC
Relief and Pilot Valves for Remote Control Circuits



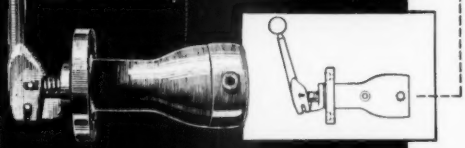
Quiet Pilot Control up to 20 feet from Control Source



YOU GET RID of the noise problem for good in remote-control hydraulic circuits when you use Denison relief and pilot valves. They're chatter-free—really QUIET—even with the control as high as *twenty feet* from the relief valve. And their quietness is matched by their accuracy. You can set up convenient remote-control panels for any number of hydraulic circuits without the annoying squeals and howls you get from ordinary hydraulic valves.

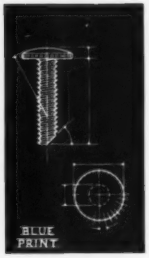
The advanced engineering of these modern, compact, *rugged* relief valves also reduces the differential between opening and closing pressures . . . brings faster action that eliminates over-pressure and pressure-drop troubles.

Denison Relief Valves are available in a variety of types for either subplate or direct connection of piping and in sizes of ¾", 1¼" and 1½". Denison Pilot Valves may be obtained for either foot or flange mounting requirements. Write for details today.



The DENISON Engineering Company
1157 Dublin Road • Columbus 16, Ohio

DENISON EQUIPMENT for APPLIED HydrOILics



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GROUND or SHAVED
Gears
. . . for lower maintenance costs

Greater accuracy in gears means lower maintenance costs in the upkeep of the machine. Sier-Bath is equipped with the latest, most efficient machinery for shaving spiral and spur gears up to 24" diameter and for grinding spur gears to 16", spiral gears to 10", splined shafts (both straight side and involute) to 42" long. Send your specs to Sier-Bath.

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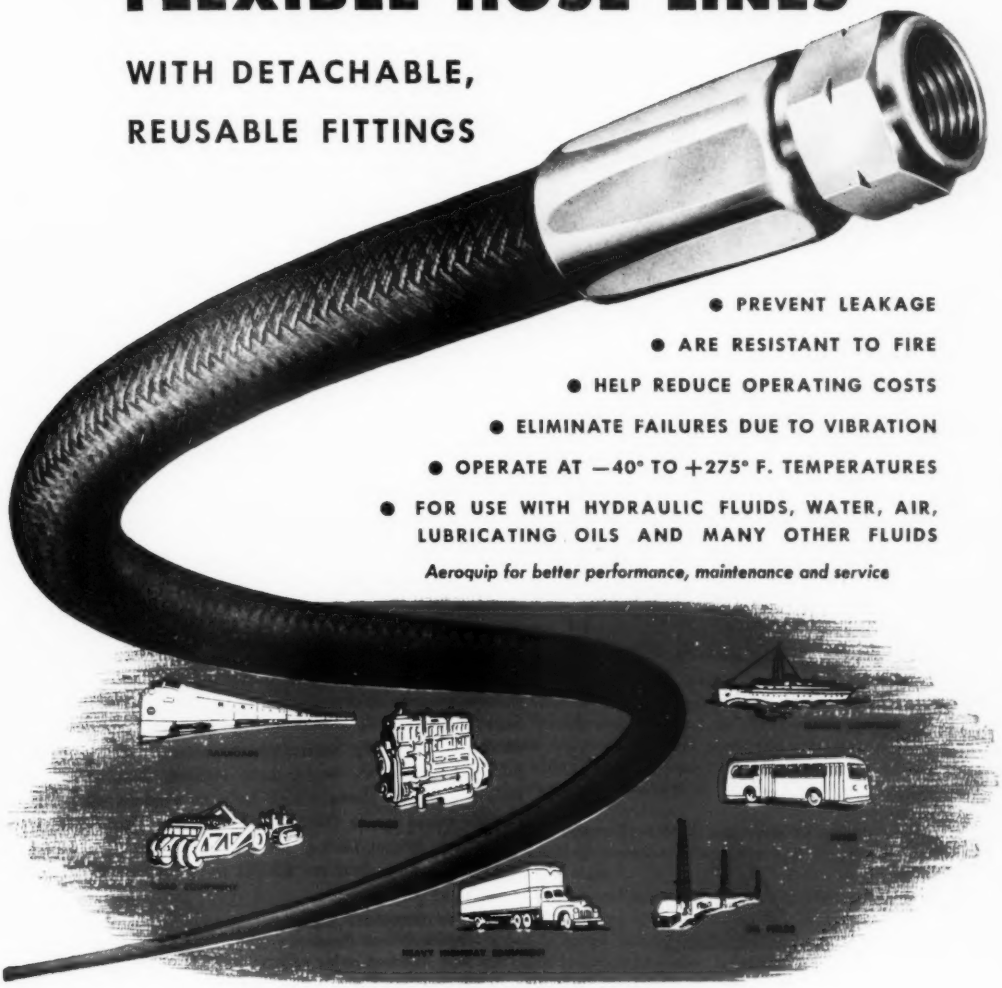
FLEXIBLE HOSE LINES

WITH DETACHABLE,
REUSABLE FITTINGS



- PREVENT LEAKAGE
- ARE RESISTANT TO FIRE
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- OPERATE AT —40° TO +275° F. TEMPERATURES
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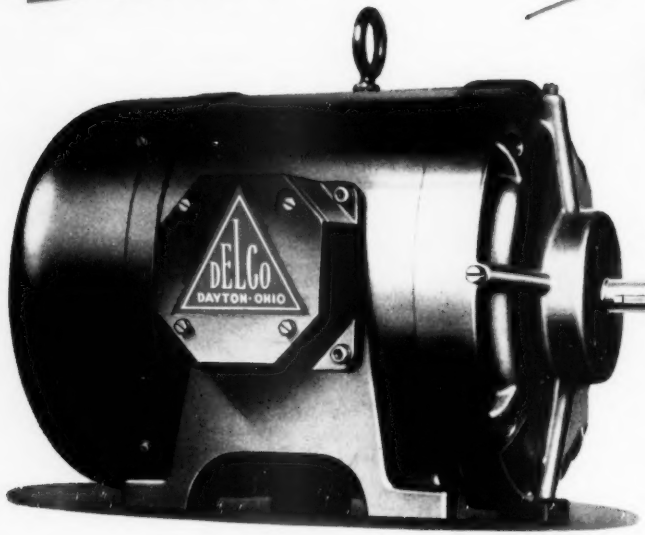
DELCO MOTORS



NEVER LET YOU DOWN

Delco polyphase motors, totally enclosed and fan cooled, are produced in sizes from fractional ratings to 75 h.p.

From both an electrical and a mechanical standpoint, Delco industrial motors are designed and built for continuous *peak performance*—there's no down-time with a Delco. The truth of this statement will be apparent to anyone making a unit-by-unit examination of a Delco and discovering among its components such engineering advancements as a double-shell, corrosive-resistant, cast-iron frame; Delcote-insulated coils; unit-cast rotor and shaft, dynamically balanced; positioned bearings; simplified lubrication; water-tight conduit box. It is *plus values* such as these which help to explain why Delco motors stand up to their jobs—why they operate *at less cost* for a *longer period of service*. You can depend on Delco for motors that are RIGHT for your individual jobs.

For complete information on Delco motors write Delco Products, Dayton, Ohio, or call our nearest sales office.

DELCO PRODUCTS
DAYTON, OHIO

DELCO MOTORS

DELCO PRODUCTS, DIVISION OF GENERAL MOTORS CORPORATION

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PRICE OF MATERIALS TOO HIGH?

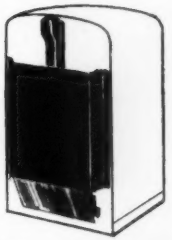
HERE'S

A

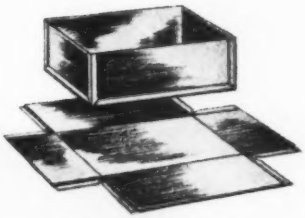
NEW SLANT

ON REDUCING

COSTS

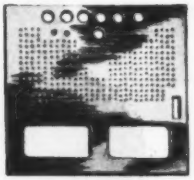


REFRIGERATOR FLUES — Designed and made by Woodall of special fibre boards . . . reduces costs . . . does a better job . . . an excellent example of adaptation of proper materials.

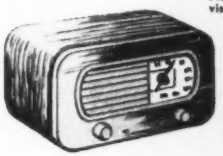


SET-UP DRAWER OR BOX—Designed and made by Woodall of Masonite Presdwoods . . . flat for shipping and storage . . . set up strong and durable . . . light weight with no rough edges . . . has a thousand uses.

SPOOL ENDS — Engineered and made by Woodall . . . A practical, economical Presdwood application . . . lightweight, inexpensive, durable.



TELEVISION BACK — Designed and made by Woodall . . . Presdwood assemblies for television sets are safe, sturdy, interference-free . . . the economy of fabricated Presdwood holds unit costs down.



RADIO CABINET—Designed and made by Woodall of various materials specifically selected for tonal qualities, durability, appearance and low cost. Finished in beautiful wood grains, decorative fabrics or in any combination of color and pattern to suit individual requirements.

AIR FAN — Engineered and made by Woodall of Masonite Presdwoods . . . lowers costs . . . quiet and efficient . . . static-free . . . another example of using materials best for the purpose.

➜ It has been proven by many of the nation's manufacturers in varied industries that *costs* can be *cut considerably* by using the material fabricating services of Woodall Industries for product pieces, parts and sub-assemblies. A few examples are shown above. There are scores of others where the materials selected and the fabricating techniques of Woodall have effected marked economies in unit production.

You'll find Woodall fabricated materials in automobiles, radios, refrigerators, trains, boats, washing machines, furniture and hundreds of other products of all kinds and sizes.

With 29 years of product and material engineering and research, skilled personnel and highly specialized equipment, and six plants geared for mass production, Woodall is in an excellent position to supply you with economical, practical parts for your products. It will pay you to find out how Woodall can help you cut your production costs. . . . Call or write WOODALL Industries, Inc., 7563 McNichols Road, Detroit 5, Michigan.

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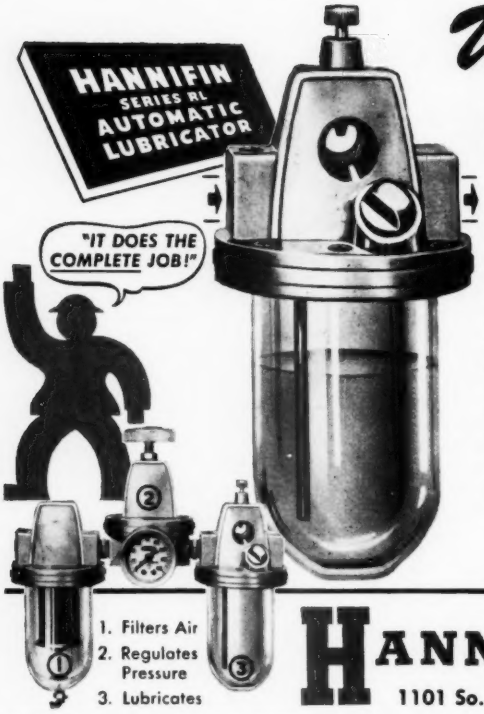
WOODALL INDUSTRIES INC.

Plants in: LONG ISLAND CITY, N. Y.—CLEVELAND, OHIO—DETROIT, MICH. MONROE, MICH.—CHICAGO, ILL.—LAUREL, MISS.



Use AIR *that's* LUBRICATED!

STOPS WEAR—Here's how to make cylinders, tools, and other air operated equipment work better and last longer. Use this new Hannifin "Air Warden" Unit! Adds atomized oil to air stream. Ends worry about lubrication of inaccessible parts.

GUARDS AGAINST RUST—Leaves film of oil covering all internal surfaces to protect against rust when equipment is shut down and idle.

SAVES TIME—Works automatically. Minimizes manual maintenance requirements. Oil supply always visible through transparent bowl. Positive shut off for filling without interrupting air flow.

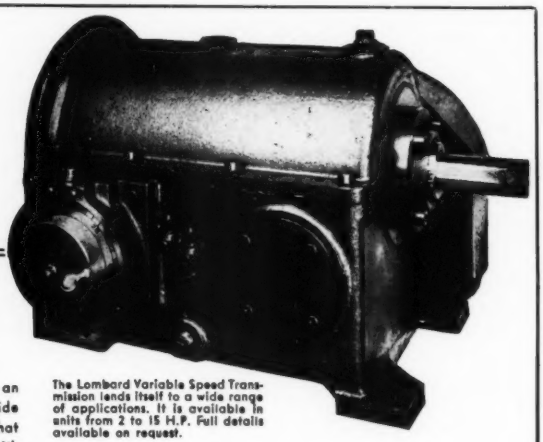
ECONOMICAL—Provides effective lubrication without waste. Uses oil only when air flows. Feed rate accurately controlled, visible, and fully adjustable. ⅜" and ½" sizes. *Send for information about Hannifin "Air Warden" equipment.*

The "Air Warden" Line

HANNIFIN CORPORATION

1101 So. Kilbourn Ave. • Chicago 24, Illinois

THE NEW LOMBARD TRANSMISSION



The Lombard Variable Speed Transmission lends itself to a wide range of applications. It is available in units from 2 to 15 H.P. Full details available on request.

. . . for applications requiring infinite variation in speeds

By incorporating the Lombard Variable Speed Reducer as an integral part of equipment, it is possible to provide a wide range of easily controlled useful speeds. Design is such that a speed range of greater than 20 to 1 can be obtained with a minimum speed approximating zero.

Power is transmitted in a straight line from input to output shafts, thereby assuring convenient application. A planetary speed reducing unit combined with the output shaft and mounted in a steel cage provides great rigidity and assures perfect alignment of gearing. All gears are enclosed and run in oil.

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Ashland, Massachusetts

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WITH CELANESE* EXTRUDED ACETATE SHEET?

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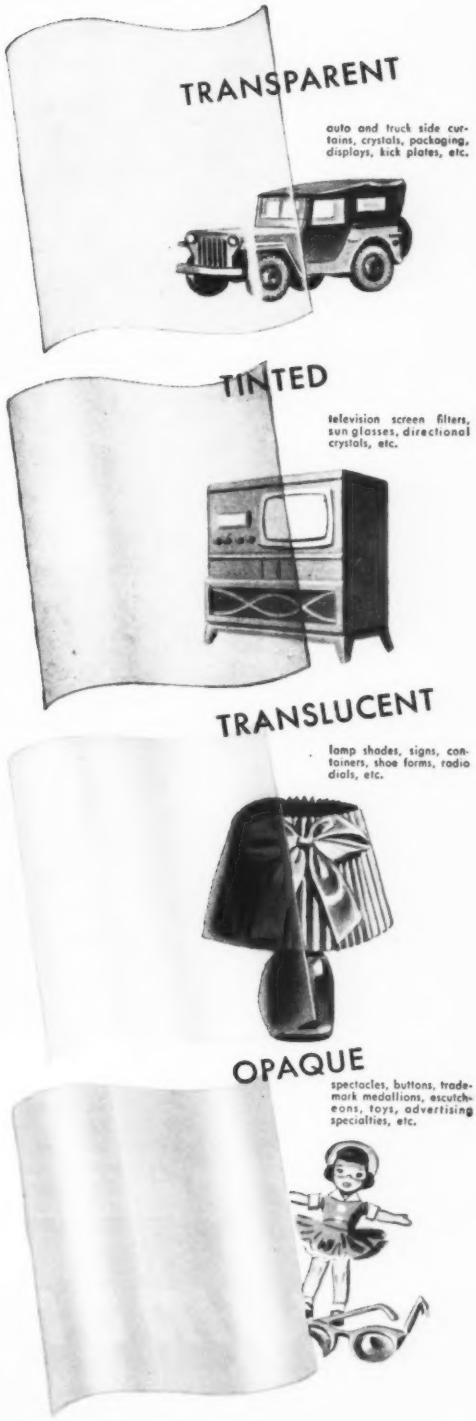
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NOW THEY DON'T LOSE THEIR "PEACHES-and-CREAM" COMPLEXION

An example for you of the cushioning power of SPONGEX Sponge Rubber

Only the best peaches get to market today. On this moving belt those not up to grade are picked out by experienced workers. But—peaches bruise easily. One processor found he was losing money because fruit rolling from hoppers onto ordinary belts was frequently damaged by the impact.

When called in on the problem, our engineers recommended surfacing the conveyor belt with soft, resilient *Spongex* sheet sponge rubber. This *Spongex* not only cushions the fruit as it falls from hoppers, eliminating bruising, it outlasts the canvas belt to which it is bonded.

Solving special problems of cushioning, sealing, insulating, sound-deadening and vibration reduction is an everyday job for *Spongex*. And *Spongex* does a better job because it's made by a company that has specialized in cellular rubber products for over 25 years.

Spongex today is used in an almost infinite number of products . . . from all kinds of molded seals and gaskets, motor suspension pads, seat cushions and backs, to weatherstripping, and rubber parts in a thousand different shapes and forms. Its resiliency, uniform cell structure, tensile strength and resistance to temperature extremes, moisture, acids, abrasion and aging make it a material worth your serious consideration. Write today, naming your product and problem. Sponge Rubber Products Co., 123 Derby Place, Shelton, Conn. Sales offices in principal industrial centers.

Trade Marks Reg. U. S. Pat. Off.

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The smart way to improve the appearance and performance of your *plastic* product or part is to tap the 39 years of experience of Northern designers, engineers and expert craftsmen. They laugh at tradition by successfully doing things "never done before". They know all molding compounds, *how* and *when* to use them, and how to mold *each* one best.

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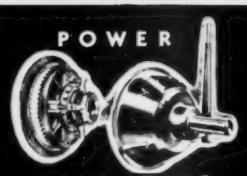

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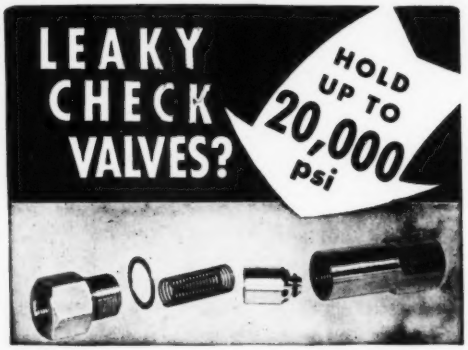

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- **Equal performance with sediment or grit**

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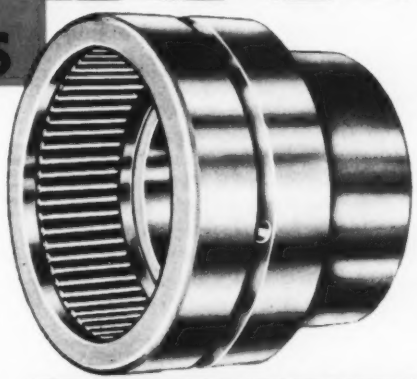
The OSGOOD "200" packs a lot of stamina in a compact, sturdy, versatile machine. It is used with ½ yd. shovel, or with dragline, clamshell, hoe or crane equipment. Osgood engineers have been using Orange Roller Bushings for several years with complete satisfaction, as inner bearings in the bevel pinions on the reversing shaft.

ORANGE ROLLER BUSHINGS



ORANGE ROLLER BUSHINGS are built ruggedly to stand up in heavy equipment, yet have the fine precision and even-running to satisfy the most exacting machine tool requirements . . . all within minimum space allotments.

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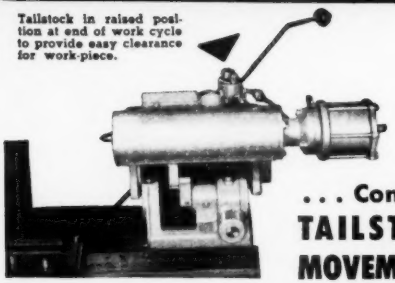
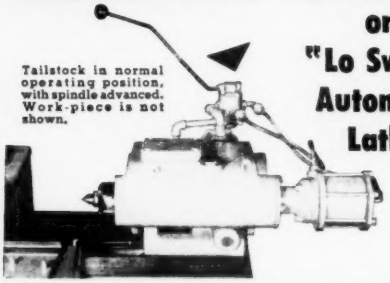
NOPAK DUAL 4-WAY VALVE



Tailstock in raised position at end of work cycle to provide easy clearance for work-piece.

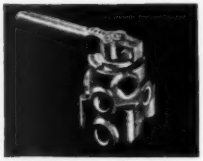
. . . Controls **TAILSTOCK MOVEMENTS** on **"Lo Swing" Automatic Lathe**



Tailstock in normal operating position, with spindle advanced. Work-piece is not shown.

Hydraulic actuation of the tailstock on this "Lo Swing" Automatic Lathe... built by Seneca Falls Machine Co. . . . greatly reduces loading and work-removal time. One NOPAK Dual 4-Way Valve controls two hydraulic cylinders which provide power for the following four movements comprising the work cycle:—1- Lowering tailstock unit to operating position; 2- Advancing tailstock spindle; 3- Retracting tailstock spindle; 4- Raising tailstock unit for clearance.

These movements are conveniently governed by easy manipulation of the extended lever on the NOPAK Dual 4-Way Valve which actuates both cylinders. This valve may be the answer to one of your "dual control" applications.



NOPAK Dual 4-Way Valve, the equivalent of two 4-Way Valves. Controls the action of two double-acting cylinders with a single operating lever.

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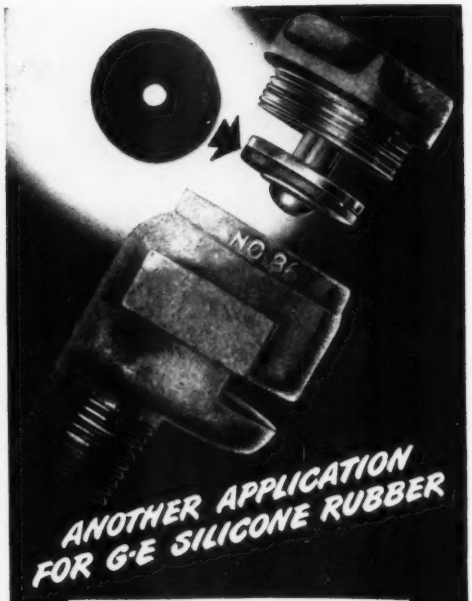
VALVES AND CYLINDERS
DESIGNED for AIR and HYDRAULIC SERVICE

A 5532-½AA



ANOTHER APPLICATION FOR G-E SILICONE RUBBER

THE SEALING DISC in this vacuum relief valve guards homes against hot water tank collapse. The manufacturer, the Watts Regulator Company, found only one material reliable enough for this important disc . . . G-E silicone rubber was the *only material* they tested which could lie dormant for as long as a year, then operate *positively* on as little as ½ inch of vacuum.

G-E silicone rubber does not stick to this valve seat, even at a pressure of 170 lbs. and temperature of 320 F. Stable and flexible from —70 F to 520 F, it won't get brittle or stick to hot clamping surfaces. That's why it makes ideal gaskets for baking ovens and vacuum systems.

You'll find excellent chemical and electrical qualities, too, in G-E silicone rubber. Find out about its new and unusual design possibilities, how it may improve your product or ease a production headache. Write for latest technical information. *Section 6-S, Chemical Department, General Electric Company, Pittsfield, Mass.*

GE SILICONE RUBBER

CD48-K4

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The original Worthington QD Junior V-Pulley clamps the shaft tighter than any other FHP V-pulley on the market.

stays tight . . . but permits easy removal

Shock or pulsating loads won't loosen the Junior QD V-pulley. The taper-bored rim, tightened on the tapered split hub, creates a positive press fit on the shaft. Yet the V-pulley is easily removed from the shaft.

Capable of transmitting power without a shaft key. Mounts easily on undersize or oversize shafts.

Bored-to-Shaft-Size FHP V-pulleys

Worthington also offers, for FHP drives, bored-to-shaft-size V-pulleys, precision-machined from solid steel in sizes 3½ in. and under . . . and from cast iron in larger sizes. All arm-type Worthington FHP Cast-Iron V-Pulleys have exclusive Worthington I Beam arm which gives you more strength with less weight.

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For adjustable-pitch drives, use Worthington Adjustable Pitch V-Pulleys, 14 sizes in single and two-groove from 3⅜ in. through 7⅜ in. O. D.

For *every* FHP drive use Worthington-Goodyear FHP V-belts, with the *HE H Y* load-carrying cord located in the *neutral* section for long life and dependable service.

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Bonderizing produces a corrosion inhibiting surface on zinc and its alloys which effectively prevents chemical reaction between the zinc and the paint ingredients.

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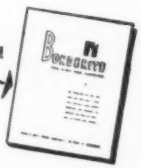

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IF apparatus porcelain costs have you stymied . . . on products either existing or planned . . . bring your problem to Locke.

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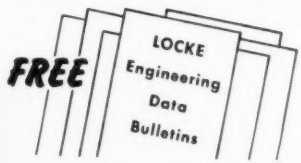

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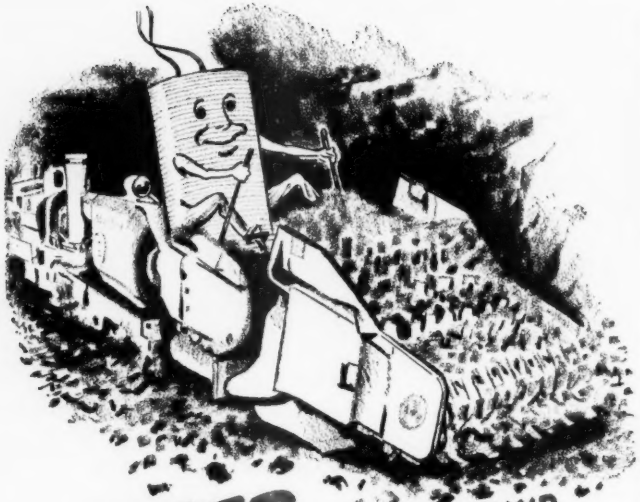

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In 25-foot long mechanical monsters capable of digging 2 tons of coal a minute, Coto-Coil Windings energize the controls which keep the machines in continuous action.

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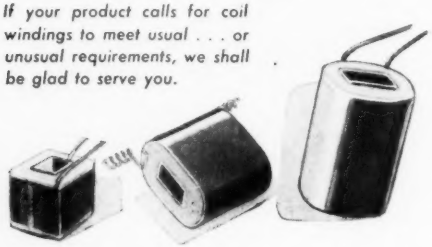
If your product calls for coil windings to meet usual . . . or unusual requirements, we shall be glad to serve you.



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In collaboration with engineers and research men of the B. F. Goodrich Company

461 pages, 445 illustrations, $6.50

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It shows you how to reduce vibrations with rubber mountings—how to determine when extruded rubber parts can be used—how to use packing and sheet rubber, etc. Its tremendous store of useful information is ready to help you find the right answers, the first time, to your specialized design and construction problems.

Stage-by-stage procedures show you how:

- **to select and use rubber adhesives**
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DIE CASTING
makes "mincemeat" of tough production problems

CASE HISTORIES FROM MT. VERNON FILES

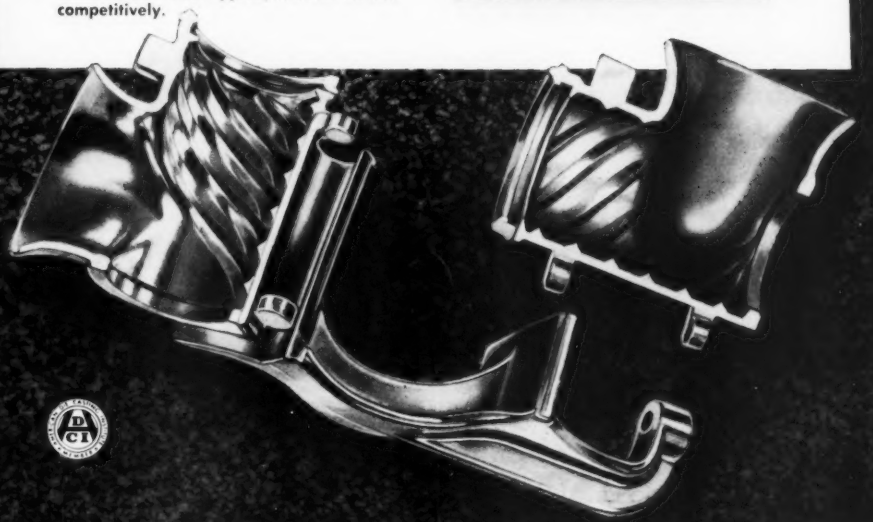
This novel "Universal" meat chopper, made by Landers, Frary & Clark, features a unique extra advantage: the chopping chamber can be swung wide open on a hinge, to permit easy, thorough cleaning. Here's an added production problem, but die casting makes light work of it.

For die casting assures rapid production, reduces need for machining and finishing, makes economical use of material without sacrifice of strength, helps to improve both performance and appearance of a product.

In fact, all the parts of this "Universal" meat chopper are die cast by Mount Vernon rapidly and economically — turned out so clean that machining operations are eliminated, and a brilliant "silver-plate" finish is obtained by simply tumbling in a ball mill. Result: A plus-value, quality product, with unusual sales appeal, that can be sold competitively.

In tackling your own manufacturing problems, remember the outstanding advantages of die casting, and consult with us. We are confident that, with our wealth of experience and modern facilities, we can show you the way to increased output, lower unit costs . . . improved products.

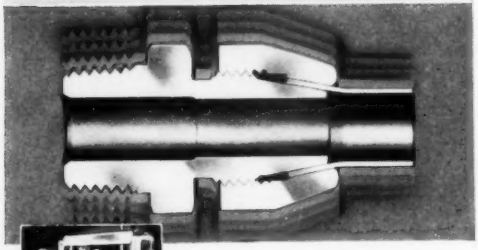
MT. VERNON
DIE CASTING CORP.
MT VERNON, NEW YORK



Vibration under high pressure?

Superseal

Flared Tube Fittings make light wall tubing practical



Jaeger Mfg. Co. compressors have Superseal Fittings.

Would you switch to light wall tubing if you could obtain fittings that withstand vibration under high pressure?

Then you'll be interested in Superseal Flared Tube Fittings which are now standard equipment on steam generators and on air compressors with pressures running up to 600 P.S.I. The same fittings in an Underwriters' Laboratories test maintained a leakproof joint under pressures up to an amazing 8090 pounds, at which pressure the steel tubing split. Grinnell Company, Inc., Providence 1, R. I.

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REPEATED DISCONNECTIONS without injury to tubing.

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99 YEARS PIPING

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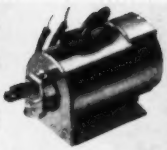

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Electrical steel is wound to form cylindrical plunger. Impregnated coil enclosed in drawn frame. Assures low iron loss in less space than conventional stacked lamination construction.

Greater flexibility in mounting. Cylindrical plunger permits clevis to be rotated to any position.

Consider this solenoid where space and cost are factors. Available with continuous duty magnet coils to 600 volts A.C.

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For

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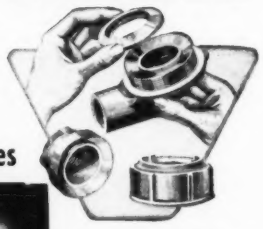
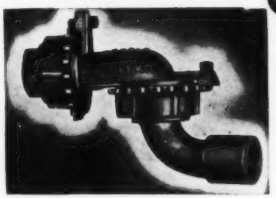
on

Swinging Pipe Lines





Style "H"

Just four simple parts! Completely enclosed from grit and dirt, Flexo Joints have no small parts, no springs—and no ground surfaces to wear. Four styles fit all standard pipe sizes from ¼" to 3".

Wherever steam, air, gas, water, oil or other fluids must be conveyed through swing joints, Flexo Joints have proven their value through safer, more dependable service. They offer complete 360° movement, with unrestricted flow in all positions—to give the flexibility of hose, the strength of pipe!

Style "A" Style "B" Style "F"

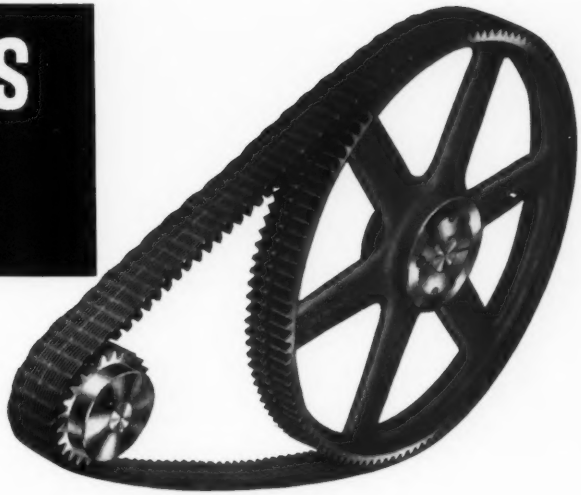
Write for details and specifications.

FLEXO SUPPLY COMPANY, Inc.

4650 Page Blvd. St. Louis 13, Mo.

In Canada: S. A. Armstrong, Ltd. 115 Dupont St., Toronto 5, Ont.

ENDLESS STORY

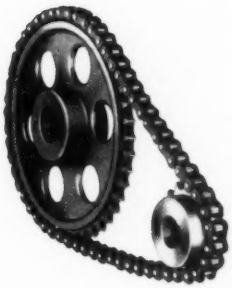


Morse Silent Chain Drives

THE STORY of Morse Silent Chain Drives is an endless one of efficiency, low cost and positive power transmission.

Perhaps the most effective known means of transmitting power between shafts, Morse Silent Chain is quiet, smooth, and dependable. Considered by engineers as flexible gearing, it has been used to transmit 5000 h.p. in a single drive; speeds have sometimes exceeded 3000 FPM. At high velocities, Morse Silent Chain Drives utilize centrifugal force to distribute driving effort over a greater number of teeth, reducing impact, wear, and noise.

Part of the story of the operating economy and long life of Morse Silent Chain Drives is found in the famous frictionless rocker joint. Employing essentially a simple rocking-chair action, Morse Silent Chain contact is confined to rolling instead of sliding action. Less heat is developed, enabling the drive to transmit heavy loads at high speeds without overheating.



Simple to connect or disconnect, Morse Silent Chains can be installed or removed without dismantling machines on which they are used. Chain length is easily and quickly adjusted for any center distance, and speed ratio changes can be readily accomplished. The initial cost of Morse Silent Chain Drives is surprisingly low, and their high efficiency and frictionless joint design assures the lowest operating cost per hour and low maintenance outlay.

Why not check the Morse Silent Chain story more completely? Write for catalog C71-48. Morse Chain Company, Dept. 353, Detroit 8, Michigan.

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Morse Roller Chain Drives • A low-cost, positive, efficient, flexible drive for use under rigorous operating conditions. Morse Standard Roller Chain is applicable to a wide range of installations and is available in all American Standard pitches and widths.

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Roller Chain Couplings

Silent Chain Drives

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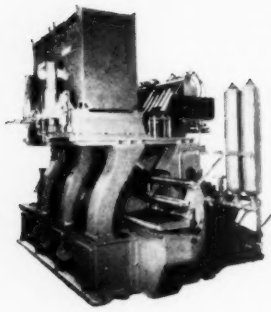
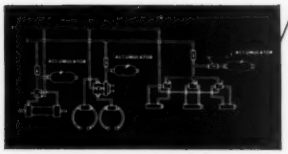
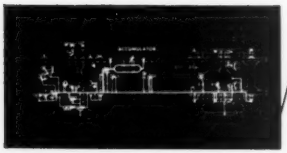


Greater Manufacturing Economy



Greater Operation Safety & Dependability



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So, each month, be sure to check through the "New Catalogs and Bulletins" and send us your requests. Without cost to you, we'll see to it that the manufacturers concerned receive your requests promptly.

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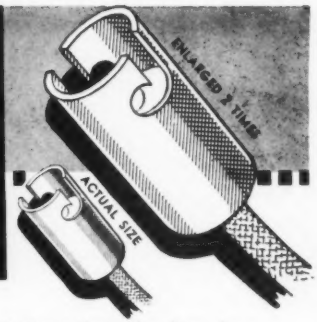
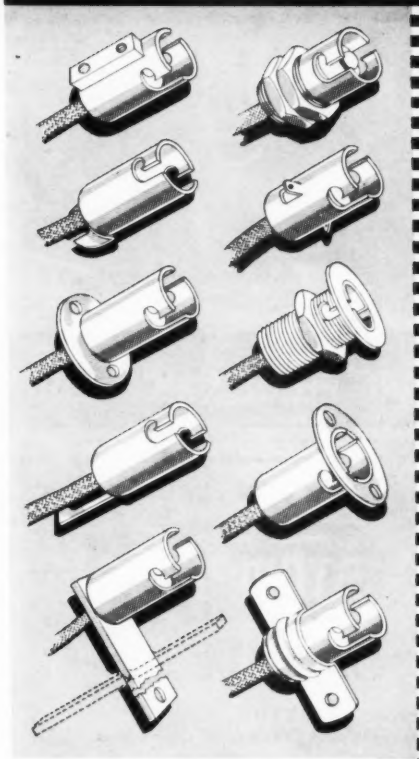
Now! the Morse Eureka MINIATURE BAYONET SOCKET of Rugged Quality and Versatility!





CAN BE FURNISHED IN ANY OF THESE SOCKET MOUNTINGS
—either in standard production or especially designed models.

The electrical manufacturing industry has long demanded a better miniature bayonet socket of sturdy, quality construction for pilot lights. Now, Morse, outstanding leader in the specialty socket field, has come up with the welcome answer.

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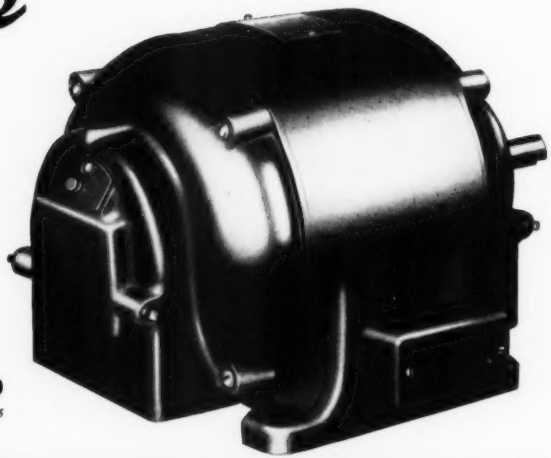

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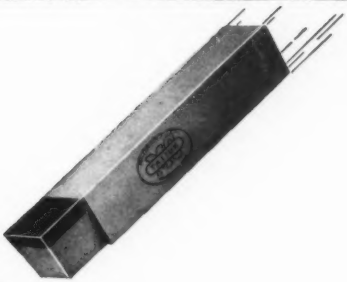

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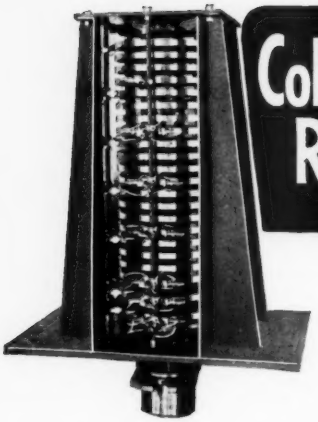

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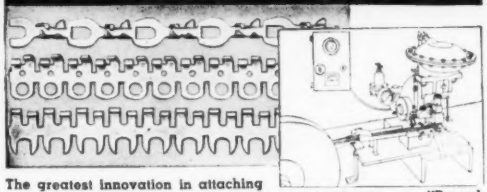

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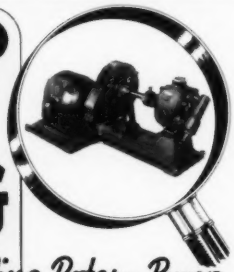

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If you are looking for pumps that will give dependable, trouble-free service, learn about Vikings! Simple gear-within-a-gear design, with two moving parts, and rugged precision construction fit Vikings for the toughest kind of pumping jobs you can have. You'll find a Viking pump in the style and size you need, correctly engineered to do the job . . . to handle any clean liquids, regardless of viscosity.

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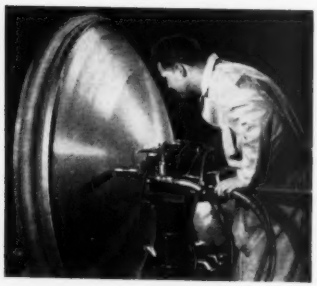

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SPEED CONTROL *for* Electrical Drives

You probably read this authoritative and helpful feature article in the January issue of PRODUCT ENGINEERING. Concisely written, it surveys performance characteristics and equipment requirements. Charts and drawings graphically illustrate important design factors discussed in its 32 pages.

For those who would like copies of this basic treatise for distribution to their technical staffs, we have a supply on hand.

Reprints in booklet form are available in limited quantities at 25¢ each from Reader Service Department.

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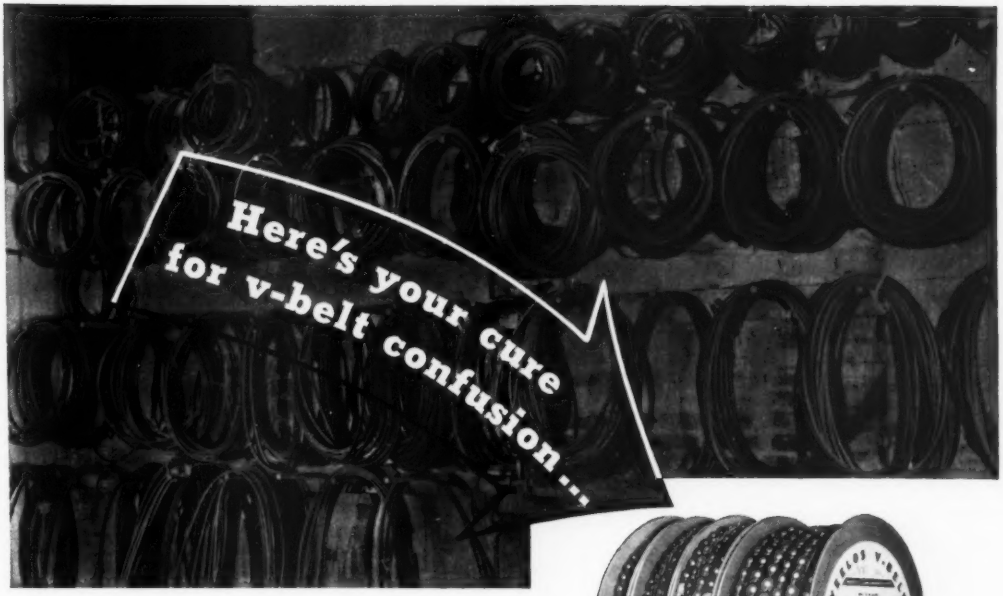

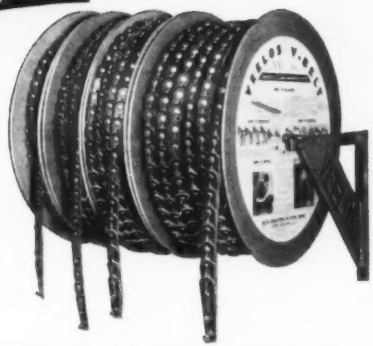

4 reels of VEELOS can replace 316 sizes of endless v-belts

HAS your v-belt inventory grown too large, too costly and too complicated by too many sizes of endless v-belts? No matter what size your inventory, Veelos can cut it—drastically!

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V-BELT

ADJUSTABLE TO ANY LENGTH • ADAPTABLE TO ANY DRIVE

Made in all standard sizes, fits all standard grooves. Packaged on reels in 100-foot lengths. Sales engineers in principal cities; over 300 distributors throughout the country. Veelos is known as VEELINK outside the United States.

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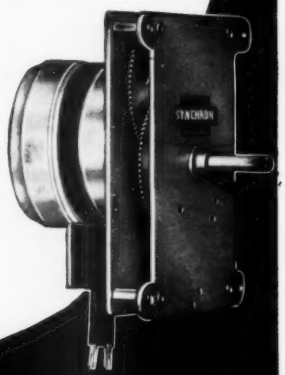
No Compromise For Quality . . .

Brass gears operate against steel pinions, babbitt bearings bathed in oil, hardened steel shafts, high precision machining, careful finishing, and minute inspection of all parts . . . these are the "plus" values in all SYNCHRON Timing motors and Time Machines which have earned the confidence of leading manufacturers of all types of timing devices.

If you have any special timing problems, feel free to call on us for suggestions. Complete engineering data sent on request.



(5-49)

HANSEN MANUFACTURING CO., INC.

Established 1907 — a Pioneer in Synchronous Motors

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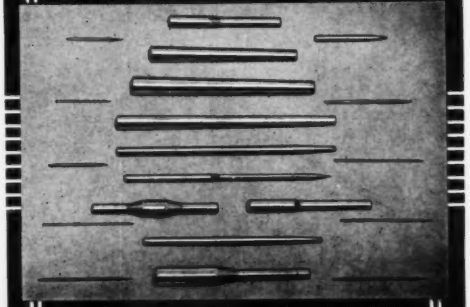
MADE TO ORDER



Tubes, Rods, Wire reduced by rotary swaging to your specifications by the pioneer rotary swaging machine builder.

Cuts show various tubes reduced, tapered and closed on end by swaging. Solid work up to ⅝" diameter and medium wall tubing up to 2½" O. D. can be handled.

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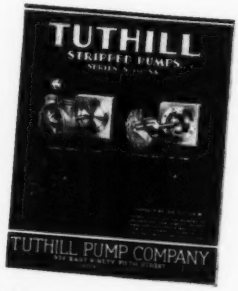
how to save space, material and money

By Using

TUTHILL

Stripped Pumps In Your Machinery Designs

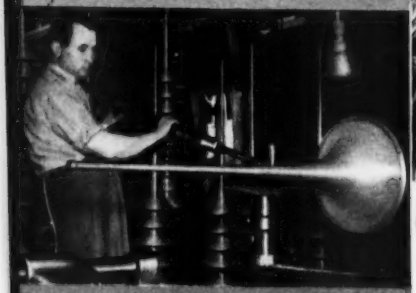


You'll find many practical suggestions for incorporating the pump directly into the design of your equipment in this Tuthill Stripped Pump bulletin. It presents the two types of stripped pumps available, designed for lubrication, coolant, hydraulic and liquid transfer service. Capacities up to 200 g.p.m. Send for your copy today.

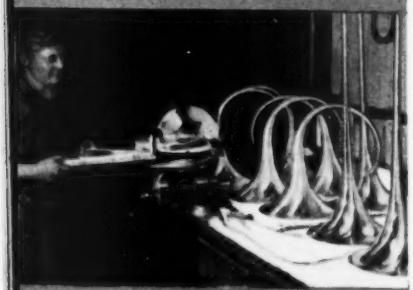
TUTHILL PUMP COMPANY

939 East 95th Street . Chicago 19, Illinois . Phone RE 4-7420

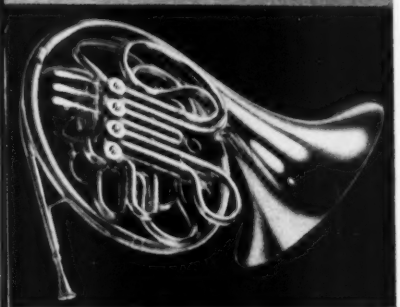
Forming the bell of a French horn is a highly skilled operation in which the bell bottom is spun from a flat disc of brass. Not only is the bell shaped, but the metal thickness is reduced.



The stem is formed from cartridge brass strip, 11" wide x .0179" thick. It is brazed on the seam and then brazed to the bell. The final spinning operation is over a tapered mandrel.



To obtain a uniformly smooth contour, both inside and out, the bell and stem are filled with pitch before bending on this bench fixture.



Skipping several hundred operations, we come to the finished instrument. It is now checked for pitch on the Conn Electronic Tester that measures tonal accuracy to 1/100th of a semi-tone.

It's BRASS that makes the Band!

When Col. C. G. Conn, the colorful Elkhart grocer who played in the town band, abandoned the cracker barrel for the tuba and the trombone in 1875, he bent his first horns to shape around tree trunks. But he started the industry that has made this nation the most musical on earth . . . a nation of three million young musicians, of 30,000 school bands and 35,000 school orchestras.

Since those early days, throughout the evolution of the Conn factory from a board shack to the largest and most modern in the world, Conn Instruments have been made from Brass and Nickel Silver supplied by The American Brass Company.

Well-known to both musicians and metal craftsmen are the many advantages that make brasses and other copper alloys indispensable for musical instruments. Only these metals can produce the tonal qualities desired . . . and only their ductility and ready workability can produce the flowing curves, the graceful tapers and glistening bells of modern band instruments.

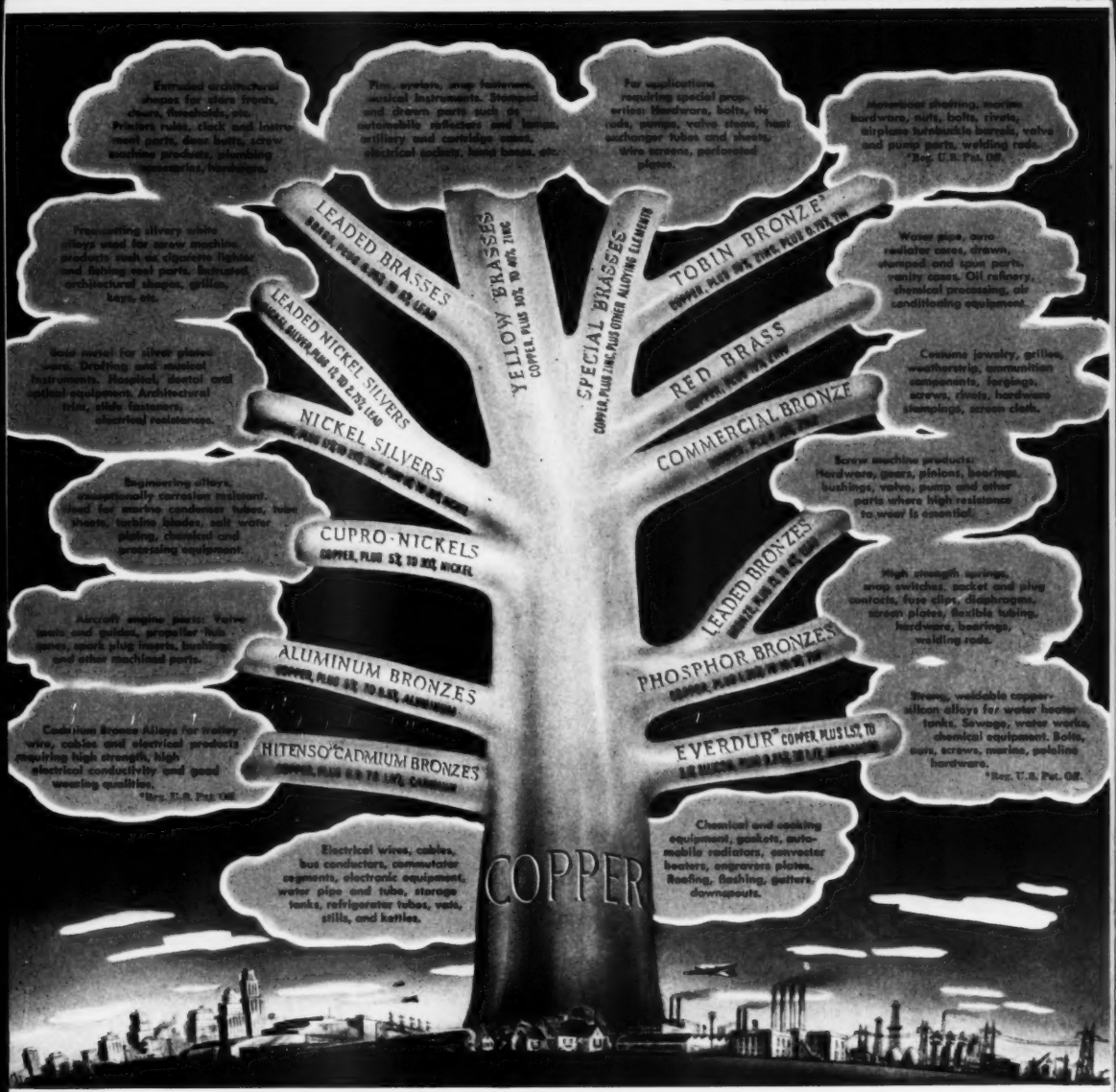
"We have always found," writes Conn, "the copper alloys furnished by The American Brass Company to be consistently uniform in the properties so essential to our operations. And when we say this, it should be borne in mind that our standards of material testing and tonal precision are without equal in our field."

Uncompromising metal standards such as those set by C. G. Conn Ltd. are the expected thing in industry after industry specifying Anaconda Copper and Copper Alloys. How varied these industries are, and the alloys they require, are graphically indicated on the next page.

ANACONDA
from mine to consumer

THE AMERICAN BRASS COMPANY

General Offices: **Waterbury 88, Connecticut**


COPPER
YELLOW BRASSES
COPPER, PLUS 30% TO 40% ZINC
SPECIAL BRASSES
COPPER, PLUS ZINC, PLUS OTHER ALLOYING ELEMENTS
LEADED BRASSES
LEADED NICKEL SILVERS
NICKEL SILVERS
CUPRO-NICKELS
COPPER, PLUS 5% TO 30% NICKEL
ALUMINUM BRONZES
HITENSO* CADMIUM BRONZES
TOBIN BRONZE*
RED BRASS
COMMERCIAL BRONZE
LEADED BRONZES
PHOSPHOR BRONZES
EVERDUR* COPPER PLUS 1 1/2% TO 3 1/2% SILICON, PLUS 1/2 TO 1 1/2% MANGANESE
Extruded architectural shapes for store fronts, doors, thresholds, etc. Printers rules, clock and instrument parts, door butts, screw machine products, plumbing accessories, hardware.
Pins, eyelets, snap fasteners, musical instruments. Stamped and drawn parts such as automobile reflectors and lamps, artillery and cartridge cases, electrical sockets, lamp bases, etc.
For applications requiring special properties: hardware, bolts, tie rods, pumps, valve stems, heat exchanger tubes and sheets, wire screens, perforated plates.
Manufacture of shafting, marine hardware, nuts, bolts, rivets, airplane turnbuckle barrels, valve and pump parts, welding rods. *Reg. U.S. Pat. Off.
Free-cutting silvery white alloys used for screw machine products such as cigarette lighter and fishing reel parts. Extruded architectural shapes, grilles, keys, etc.
Base metal for silver plated ware. Drafting and musical instruments. Nautical, dental and optical equipment. Architectural trim, slide fasteners, electrical resistances.
Engineering alloys, exceptionally corrosion resistant. Used for marine condenser tubes, heat sheets, turbine blades, salt water piping, chemical and processing equipment.
Aircraft engine parts: Valve seats and guides, propeller hub bores, spark plug inserts, bushings and other machined parts.
Cadmium Bronze Alloys for trolley wire, cables and electrical products requiring high strength, high electrical conductivity and good wearing qualities. *Reg. U.S. Pat. Off.
Water pipe, auto radiator cores, drawn, stamped and spun parts, vanity cases. Oil refinery, chemical processing, air conditioning equipment.
Costume jewelry, grilles, weatherstrip, ammunition components, forgings, screws, rivets, hardware stampings, screen cloth.
Screw machine products: Hardware, gears, pinions, bearings, bushings, valve, pump and other parts where high resistance to wear is essential.
High strength springs, snap switches, socket and plug contacts, fuse clips, diaphragms, screen plates, flexible tubing, hardware, bearings, welding rods.
Strong, weldable copper-silicon alloys for water heater tanks. Sewage, water works, chemical equipment. Bolts, nuts, screws, marine, pole line hardware. *Reg. U.S. Pat. Off.
Electrical wires, cables, bus conductors, commutator segments, electronic equipment, water pipe and tube, storage tanks, refrigerator tubes, vats, stills, and kettles.
Chemical and cooking equipment, gaskets, automobile radiators, convector heaters, engravers plates. Roofing, flashing, gutters, downspouts.

Copper is the trunk of an indispensable family tree

The copper family of alloys is versatile, indeed. These dependable metals have contributed to the development of practically all technical and industrial progress. Other metals may have more distinctive properties. Chromium is harder; magnesium is lighter; silver has higher conductivity. But . . . of all commercial metals, copper and its alloys *combine to best advantage* a range of physical and chemical properties not found in any other group.

These properties include a high degree of corrosion resistance; high tensile strength and fatigue resistance; ductility, hardness and toughness; ready weldability; resistance to abrasion; hot or cold workability; machinability, and high thermal and electrical conductivity.

Yet, these very properties, singly or in combination, can be varied considerably by metallurgical adjustment of composition and by changes in the technique of fabrication.

Our Technical Department will be glad to work with you in selecting the best metal for a specific application. 48123

ANACONDA THE AMERICAN BRASS COMPANY

General Offices: Waterbury 88, Connecticut

Subsidiary of Anaconda Copper Mining Company

In Canada: Anaconda American Brass Ltd., New Toronto, Ont.

Anaconda Copper Alloys

Makings of a Plastics Fan

It keeps happening! Meet Robbins & Myers, the newest Kurz-Kasch fans—enthusiastic, appropriately enough, because of what plastics have done for their great floor fan, the "Breeze-All."

The "Breeze-All" is unique in appearance and performance. Handsome, rich-looking and quietly powerful, it continuously delivers cool, floor-level air throughout large rooms. And its success story is matched by the success story of its plastic parts.

There are two, as pictured, both of them good-sized—the lustrous, rich top cover, 15½" in diameter, and the baffle cone, 6½" in depth of draw. Together, they double as motor housing and table top, and are easily assembled as structural members for a unit capable of supporting a 750 lb. weight. They're attractive, sufficiently strong, and considerably less expensive than either stampings, die-castings or spinnings.

Along with R&M, you'll find many other leading manufacturers—in greatly diversified fields—listed among Kurz-Kasch customers. They seem to like the Kurz-Kasch way of handling production, meeting inspections, fulfilling shipping schedules. We've been doing it for decades—have complete facilities for any compression, transfer or plunger-moulding job. We can handle yours right now.

Kurz-Kasch

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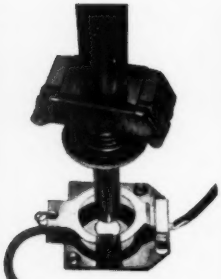
BRANCH SALES OFFICE: New York, *Lexington 2-6677* Chicago, *Harrison 5473* • Detroit, *Woodward 2-5214* Philadelphia, *Granite 2-7484* • Dallas, *Lakeside 1022* Los Angeles, *Prospect 7503* • St. Louis, *Rosedale 3542* Toronto, Canada, *Adelaide 1377.*

EXPORT OFFICES: 89 Broad Street, New York City, *Bowling Green 9-7751.*

THIS CENTRIFUGAL STARTING SWITCH assures a lifetime of perfect starts. Opens gently but positively. Large oversize contacts are made of silver much finer than sterling. Quiet, dependable, long-lived, this switch gives you the trouble-free performance you want for your equipment.



Designer's Dream

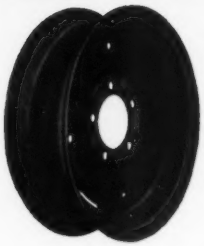
Yes, K-C Motors meet the equipment designer's most modern requirements in styling. The real beauty is that they're just as good as they look, too. Rugged and tough, these powerful units deliver quiet, smooth, cool performance even under difficult conditions of high overload and continuous operation. They're versatile, adaptable and designed for use when and where you want them on your equipment. Write us for complete details.

THE HOOVER COMPANY
Kingston-Conley Division
86 Brook Avenue, North Plainfield, New Jersey

K-C Motors

A Product of The Hoover Company. Built in ratings of ¼, ⅓, ½, ¾, 1 and 1½ H.P. at 1725 R.P.M. and 2 H.P. at 3450 R.P.M. in single phase. Also companion polyphase motors.

STOP! Don't throw those old AUTO TIRES away



A GREAT NEW IDEA

Here's a 15" diameter IMPLEMENT WHEEL that takes discarded automobile tires — high pressure 5.50, 6.00 and 6.50. Dealers note. Farmers note.

100955
5" BOLT—5½" BOLT CIRCLE
15 x 5" K WHEEL

4902 SEAL

4715 HUB ASSEMBLY
5—3965 STUDS
5—3638 NUTS
1—09195 CUP
1—14276 CUP

14136A CONE

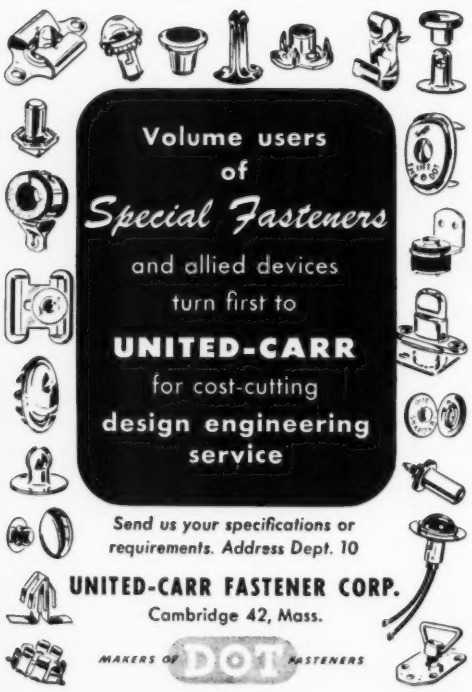
09078 CONE

4719 CAP

and STANDARD 1⅜" SAE 1045 COLD ROLLED CENTERLESS GROUND SPINDLES

IMMEDIATE DELIVERY

FRENCH & HECHT
DIVISION
KELSEY-HAYES WHEEL COMPANY
DAVENPORT, IOWA
Wheel Builders Since 1888



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UNITED-CARR FASTENER CORP.
Cambridge 42, Mass.

MAKERS OF DOT FASTENERS

JOHNSON SLEEVE BEARING DATA

Bearing DESIGN

BRONZE SLEEVE BEARING DATA

Clearances

OIL CLEARANCE in sleeve-type bearings is that difference in size between the diameter of the shaft and the inside diameter of the bearing. This space accommodates the lubricant, permits the formation of a protective oil film preventing metal-to-metal contact when in operation and allows for expansion due to heat. Bearing performance, bearing life and machine operation are all greatly affected by oil clearances determined through correct dimensions of shaft and bearing.

It is quite impossible to set hard and fast rules for all applications. So many factors go into the successful operation of bearings that each should be given individual study and clearance data decided from the findings. However, certain general standards can be used as a guide towards correct oil clearances.

The above chart lists the average oil clearances most widely used for internal combustion engine applications. This applies to units in which a force feed, pressure lubrication system is used. The vertical clearance is generally maintained to low limits whereas higher clearance is maintained at split line, accomplished by eccentric bore or reliefs at parting line. For splash lubricated bearings, where the engine speed is less than 2000 R. P. M., the minimum oil clearance will be somewhat larger, varying from .0002 to .0006 per inch of shaft diameter.

INTERNAL COMBUSTION ENGINE BEARINGS

Dia. of Crankshaft Journal or Crankpin	*Oil Clearance between shaft and bearing on diameter*	*Crankshaft End Clearance*
2" to 2¾"	.0015 ± .001	.004 to .006
2 13/16" to 3½"	.0025	.006 to .008
3 9/16" to 3¾"	.003	.008 to .010
3⅞"	.0035	.008 to .010
4"	.004	.008 to .010

*This data computed on the use of white or babbitt metals.

Ordinary industrial applications can be governed by general clearance practice—as listed below. We have found, through more than 40 years exclusive bearing manufacturing experience, that the majority of applications can be so classified. The tolerance range, as shown by the chart, provides ample room for the formation of a protective lubricating film. In certain specific applications, such as some types of machine tools engaged in producing very precise parts, clearances must be held to very close limits.

There is one sure way of removing doubt concerning tolerances and oil clearances. Call in a Johnson Bronze Engineer. We are interested in giving you bearings that will suit your applications—bearings that will deliver greater performance and longer bearing life. Our men are trained in all phases of bearing practice. We offer their services to bearing users without obligation of any kind.

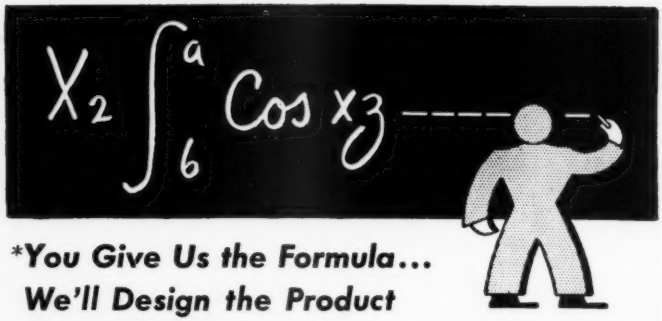
BEARING CLEARANCES IN INDUSTRIAL APPLICATIONS

CLASS OF BEARING	*Running Clearance, Thousandths of an inch, for shaft dia. under*				
	½"	1"	2"	3½"	5½"
Precision Spindle Practice—Hardened & ground spindle lapped into the bronze bushing. Below 500 ft./Min. & 500# Sq. In.	.00025 to .0075	.00075 to 0015.	.0015 to .0025	.0025 to .0035	.0035 to .005
Precision spindle practice—Hardened & Ground spindle lapped into bronze bushing. Above 500 ft./Min. & 500# Sq. in.	.0005 to .001	.001 to .002	.002 to .003	.003 to .0045	.0045 to .0065
Electric Motor & Generator Practice—Ground Journal in broached or reamed bronze bushing or reamed Babbitt bushing	.0005 to .0015	.001 to .002	.0015 to .0035	.002 to .004	.003 to .006
General Machine Practice (Continuous rotating motion)—Turned steel or cold rolled steel Journals in bored & reamed bronze or poured & reamed babbitt bushings	.002 to .004	.0025 to .0045	.003 to .005	.004 to .007	.005 to .008
General Machine Practice (Oscillating Motion)—Journal & Bearing material as above	.0025 to .0045	.0025 to .0045	.003 to .005	.004 to .007	.005 to .008
Rough Machine Practice—Turned steel or cold-rolled steel Journals in Poured babbitt bearings	.003 to .006	.005 to .009	.008 to .012	.011 to .016	.014 to .020

This bearing data sheet is but one of a series. You can get the complete set by writing to—

Johnson Bronze

SLEEVE BEARING HEADQUARTERS
508 S. MILL ST. • NEW CASTLE, PENNA.



You Give Us the Formula...
We'll Design the Product

SERVING YOUR NEEDS FOR:

- **A** Computers . . . mechanical brains that instantly solve the settings for perfect machine operation.
- **B** Servomechanisms . . . that automatically translate computed settings into actual control positions and adjustments.
- **C** Scientific Instruments to your performance specifications.
- **D** Technical Reports.

* In fact we'll figure the *formula* for you, too!

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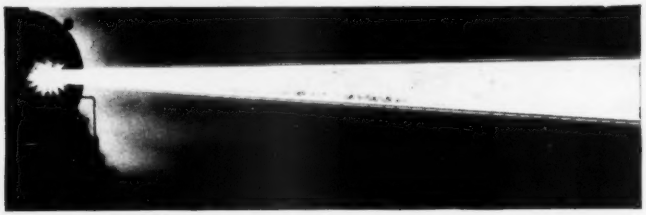

HOW MANY MILES IN A SILVER LINING?

HUNDREDS of thousands *more*, thanks to ingenious railroad headlight manufacturers. Reflectors stay mirror-bright through thousands of polishings without wearing away silver lining applied *behind flawless glass*. McKee has supplied a large proportion of these flawless glass reflectors for many years.

McKee supplies many other industries with quality-controlled glass items for assembly into finished products—television mirror blanks, appliance window panels, mixing bowls, urn liners, and many, many others. McKee produces many close-tolerance machinery parts, too, such as glass godet spinning wheels for rayon, to improve processes, cut costs.

McKee offers you almost a hundred years of know-how in glassmaking. We will make glass to your established design . . . help you design new items . . . develop glass to meet your specific needs.

If you already use industrial or commercial glass . . . if you think you might do so profitably, call on us.

Reflector Mirror Blanks. Volume-produced in many sizes and kinds for all types of searchlights. Made of McKee Glasbake Brand borosilicate glass. Strong, heat-resistant. Molded and pressed to exact specifications to minimize grinding and polishing required for silvering.

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ESTABLISHED 1853
PRODUCT DEVELOPMENT DIVISION
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- Bearings and gears
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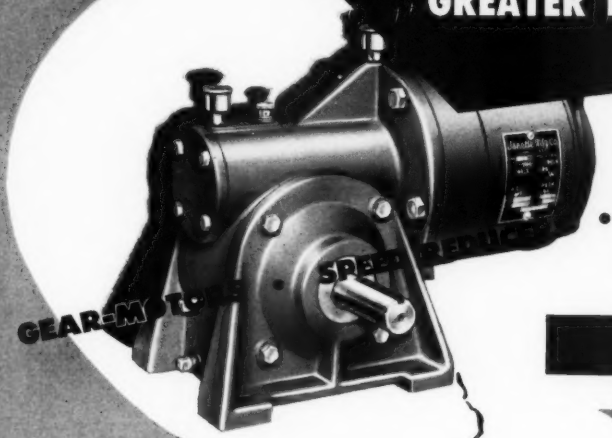

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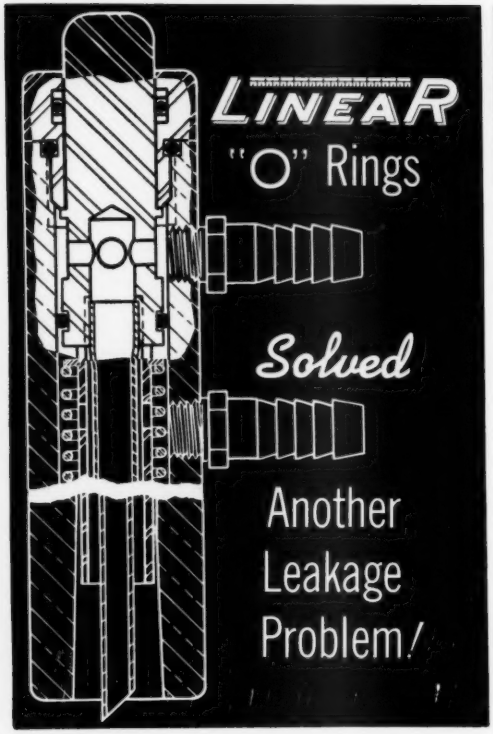

The LINEAR "O" rings used in the P. R. Mallory Resistance Welding Electrode Holder make it completely leakproof. They prevent cooling water from dropping on the material being welded, where it could cause rust and discoloration on the finished product.

Previous holders used a packing which tended to dry out when not in use . . . when dry, it compressed to a point where it would not make a perfect seal. LINEAR "O" rings solved this difficult problem . . . they retain their size and shape making a perfect seal when the holders are in use —or idle.

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Whatever your design problem with wire cloth for mechanical or structural parts, call on Wickwire Brothers, Inc. — specialists in wire manufacturing since 1873 — for experienced information. Wickwire's CORTLAND Brand Industrial Wire Cloth is made to meet your specifications —

Sizes: One inch to 30 Mesh
Weaves: Square and special
Metals: Steel, Copper, Brass, Bronze, Aluminum, Stainless Steel, etc.
Gauge: 14 to 39 and special
Finish: Tinned, galvanized, painted or plain steel.
Widths: 24"-48" standard; also narrower or wider, and slit or cut to size.

Inquiries about special grades and special applications are welcomed. Cortland Brand Industrial Wire Cloth can help you build your product better.

WB Cortland BRAND

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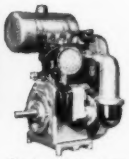
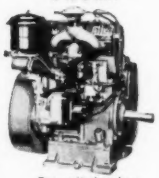
Heavy-Duty *Air-Cooled* Engines

Offer Reputability

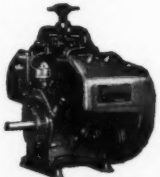
TO MATCH YOUR OWN . . .



Single cylinder sizes 2 to 6 H.P.



Two cylinder sizes, 7 to 13 H.P.



V-type 4-cylinder sizes, 15 to 30 H.P.

If your company manufactures power-operated equipment of any kind that can utilize engine power within a 2 to 30 Horsepower range . . . your good name is safe when the performance of your equipment is entrusted to Wisconsin Air-Cooled Engines.

Here is reputability to match your own, no matter how high or exacting your standards may be. Every Wisconsin Engine from the smallest to the largest is of heavy-duty design and construction. The perfectly balanced drop-forged crankshaft of every Wisconsin Engine runs on tapered roller bearings at *both* ends to take up end- and radial thrusts . . . a typical detail of Wisconsin heavy-duty design that assures the user "Most H.P. Hours" of on-the-job service.

Wisconsin Heavy-Duty Air-Cooled Engines are available in 4 cycle single cylinder, 2- and 4-cylinder types in a complete power range up to 30 H.P.

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World's Largest Builders of Heavy-Duty Air-Cooled Engines

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Alloy
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Equipment

Gives thousands of hours' service

HASTELLOY nickel-base alloys are being used more and more where elevated temperatures and thermal shock are combined with corrosive conditions. Cyaniding baskets and racks, for example, give months of service when made of HASTELLOY alloy sheet. For these alloys are strong, ductile materials that resist the effects of extreme heat and repeated quenching, as well as the corrosive action of molten cyanide.

If your operating conditions demand a metal that will resist scaling and corrosion and maintain high mechanical strength at elevated temperatures, one of the four grades of HASTELLOY alloy may solve your problem. These alloys are available in all standard forms and can be readily fabricated by most common methods. For descriptive literature and price lists, contact our nearest district office.

PART: Cyaniding Basket
ALLOY: "HASTELLOY" A
BATH TEMPERATURE: 1550 deg. F.
COOLING: By dumping in water
LIFE: 3 years

PART: Cyaniding Rack
ALLOY: "HASTELLOY" A
BATH TEMPERATURE: 1625 deg. F.
COOLING: In oil
LIFE: 1 year

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TRADE-MARK
alloys

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Unit of Union Carbide and Carbon Corporation
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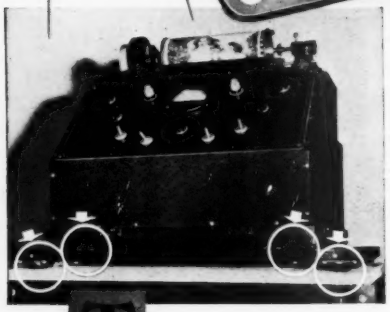
The trade-marks "Haynes" and "Hastelloy" distinguish products of Haynes Stellite Company.



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Whether your product needs protection and isolation from outside vibratory forces or control of vibration created by its own movements Lord engineers can help you.

See our bulletin in Sweet's 1949 File for Product Designers or write for Bulletin 900 today. It describes the complete line of Lord products and services.

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LORD Vibration Control Systems

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MODERN, COMPACT
SNAP-ACTION T-70 THERMOSTAT

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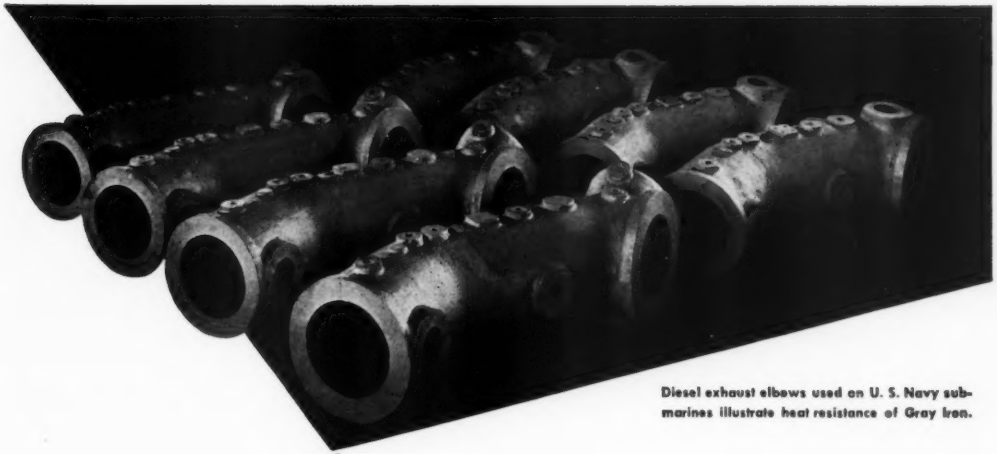

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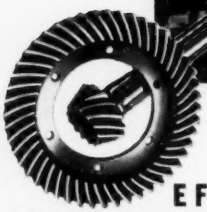

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756-2

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Engineering data on the design of ultrasonic systems

Considers the many uses of ultrasonics in industry

HERE is the first engineering consideration of the ultrasonic field . . . the essential theory, plus an abundance of practical information never before published! This important new book reviews electronic considerations and outlines of circuits. Mechanical and electrical design and construction techniques of ultrasonic systems are included . . . everything from the design considerations of holders for ultrasonic use to the experimental measurement of ultrasonic waves in various media.

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Brought out of the research laboratory and into industry, ultrasonics has tremendously broad, practical applications. This guide points the way to greater use of ultrasonics in, for example, MATERIALS TESTING; to detect flaws in metals, plastics and glass, etc.; CHEMICAL INDUSTRIES; to make better mixtures and emulsions, etc.; METALLURGY; for extremely uniform mixtures free of air bubbles, etc. It likewise discusses experimental applications to systems of television, underwater signaling, depth sounding, communication, destruction of bacteria, etc.

CONTENTS

1. Ultrasonic Waves
2. Ultrasonic Waves: Further Theory
3. Crystals for Ultrasonic Use
4. Crystal Holders for Ultrasonic Use
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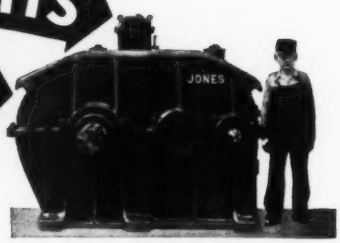

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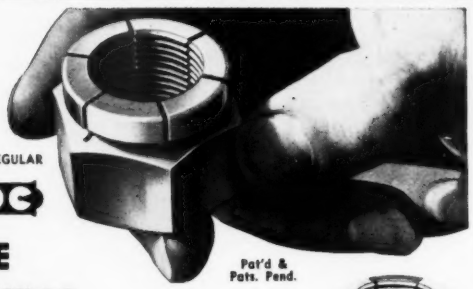

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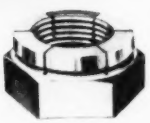

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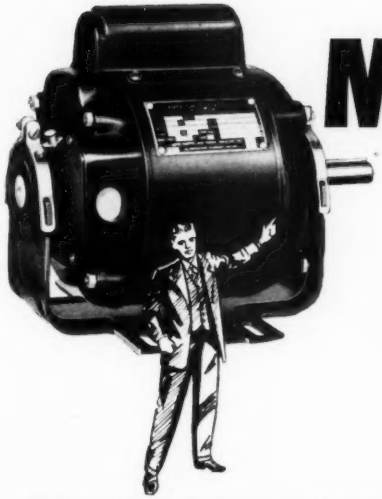

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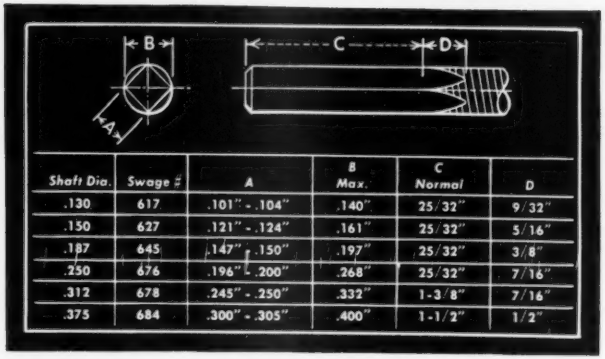
INTEGRAL FORMED DRIVE SQUARES ON A WIDER RANGE OF FLEXIBLE SHAFT SIZES



Shaft Dia.	Swage #	A	B Max.	C Normal	D
.130	617	.101" - .104"	.140"	25/32"	9/32"
.150	627	.121" - .124"	.161"	25/32"	5/16"
.187	645	.147" - .150"	.197"	25/32"	3/8"
.250	676	.196" - .200"	.268"	25/32"	7/16"
.312	678	.245" - .250"	.332"	1-3/8"	7/16"
.375	684	.300" - .305"	.400"	1-1/2"	1/2"

S.S.White is now prepared to furnish flexible shafts with integral formed drive squares in the larger diameters of ¼", 5/16" and ⅜". Added to the regular line of smaller shaft sizes, the new additions provide a wide assortment as indicated by the table above.

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The June issue of PRODUCT ENGINEERING will be completely devoted to this very important subject. Watch for it. This issue seems sure to set a new high mark in industrial publishing.

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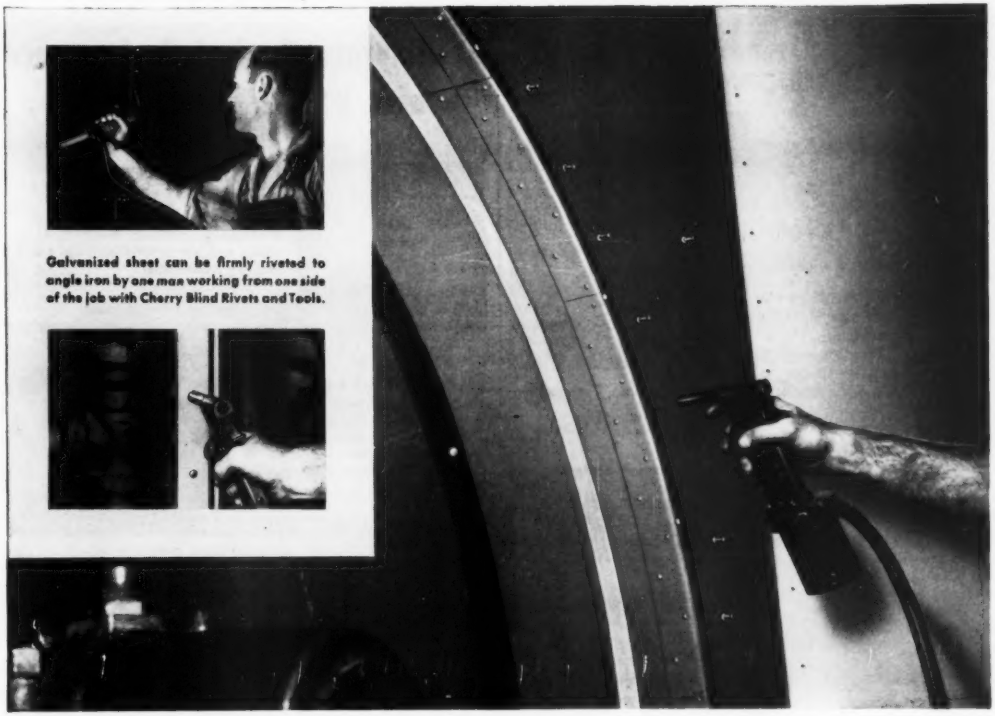
PRODUCT ENGINEERING



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324 standard

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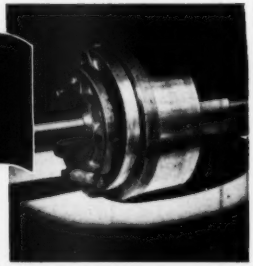
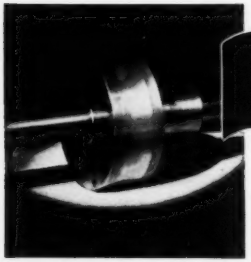
CLUTCH



Unequalled for accurate control of intermittent machine operations — cutting, punching, and packaging. Gives closer tolerances to cut-off, stamping, shearing, and similar machines. Completely automatic; manual, mechanical, or electrical control.



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Hilliard Over-Running Clutches and Couplings are automatic in operation. They are unexcelled for automatic two-speed drives, dual drives, stand-by drives, and for allowing machinery to "coast" after drive stops. Excellent as fixed or infinitely adjustable ratchets.

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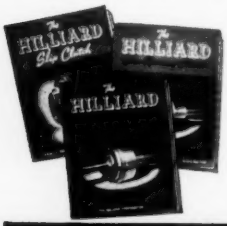
A reliable series of spring-loaded slip clutches and couplings. Rugged construction with ample friction surface for heavy-duty use. Outstanding for preventing overloads and shocks; for starting heavy loads; as tension drag brakes; for reeling and winding operations; and many other uses.



Hilliard's Engineering Department is ready to assist you in designing installations and in selecting the correct clutch or coupling.
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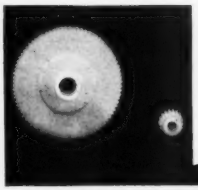
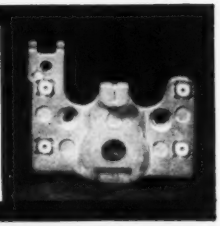
HOW TO

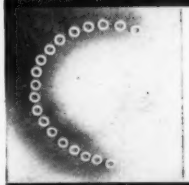
Improve Product Performance with NYLON Rod and Strip



GEARS machined from Nylon Rod have excellent wear resistance, operate quietly and do not require lubrication.

BUSHINGS for tuning devices are machined from Nylon Rod, staked into place and tapped. They have the toughness to withstand staking and the heat resistance that gives long product life.





WASHERS for holding commutator segments are stamped from Nylon Strip at minimum tooling cost. Use of nylon permits reduction in size without loss of strength, and gives heat resistance to withstand nearby soldering during assembly.

ROLLERS for aircraft use are made from Nylon Rod for a number of reasons: light weight, wear resistance, good frictional properties.

For economy along with product improvement, think about these advantages you get with Nylon Rod and Strip.

You *eliminate the need for costly molds* on short run jobs. You save time in production, with nylon that is *easy to machine or stamp*. And you avoid long waits for new molds when designs are changed.

Free Folder of Useful Engineering Data

A note on your company letterhead will bring you this folder containing useful data on the physical properties and fabricating characteristics of Nylon Rod and Strip, available in several formulations.

the POLYMER CORPORATION
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201 GANSTER BUILDING, READING, PENNSYLVANIA

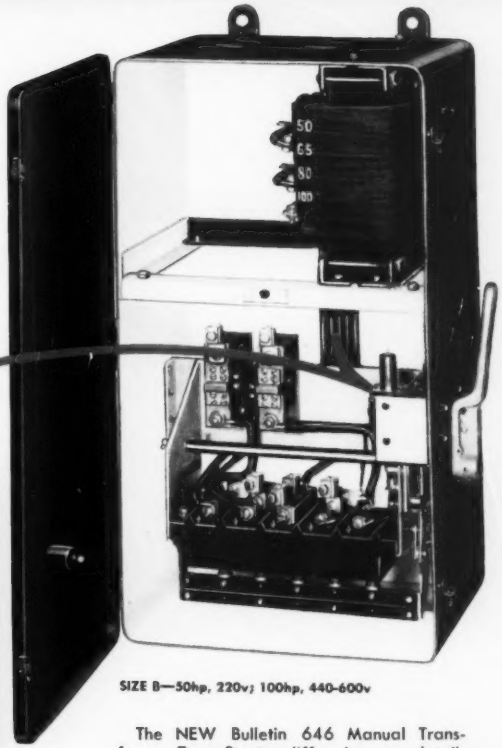
NEW

Bulletin 646

Manual Transformer-Type Reduced-Voltage Starter

Here is the first outstanding improvement in manual transformer-type starters in twenty-five years. It is a worthy addition to the Allen-Bradley line of motor controls.

An unusual feature is its adjustable time delay, which prevents careless operators from switching the motor too quickly to full running voltage. Many other features are described on the next page.



SIZE B—50hp, 220v; 100hp, 440-600v

The NEW Bulletin 646 Manual Transformer-Type Starter differs in many details from older types of reduced-voltage starters.

Time-tested developments . . . like Allen-Bradley double break, silver alloy contacts . . . assure long, trouble-free service. See next page for further details.

Allen-Bradley Co., 1316 S. Second Street, Milwaukee 4, Wis.

ALLEN-BRADLEY

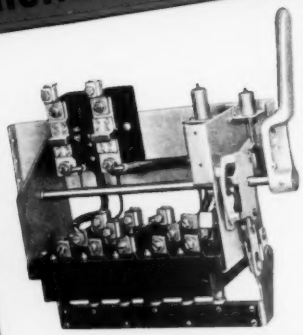
BULLETIN 646 TRANSFORMER-TYPE STARTER

QUALITY

TURN
see next page

EXCEPTIONAL FEATURES *of the*

Bulletin 646 Manual Transformer-Type Starter



TIME DELAY SWITCHOVER

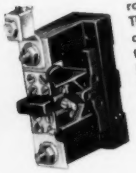
The Bulletin 646 switching mechanism is a simple, mechanical linkage operated by a two-position, manual starting lever. When the lever is pulled forward, the switch mechanism moves the contacts into the "Start" position. This permits the motor to accelerate at reduced voltage.

An interlock, under dashpot control, prevents the starting lever from being thrown into the "Run" position until the motor has accelerated for several seconds. This timing is adjustable to suit varied starting conditions.

No-voltage protection is also provided by a magnetically operated hold-in latch. Man, motor, and machine are fully protected against accidents and damage from line failures.

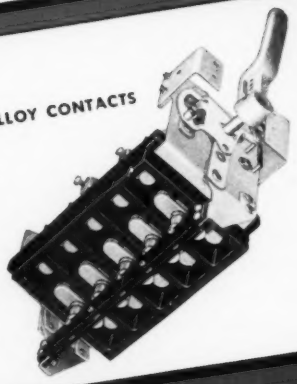
DEPENDABLE OVERLOAD RELAYS

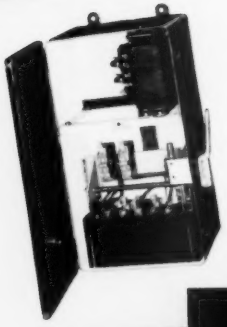
The accurate, reliable overload relays operate on the soldered ratchet principle. They remain reliable in operation, even after long inactivity. Thermal elements available for any load. Contacts are pure silver.



DOUBLE BREAK, SILVER ALLOY CONTACTS

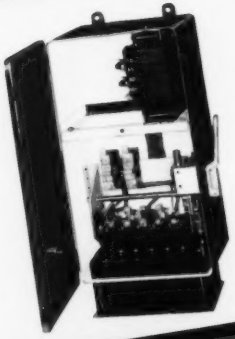
Starting and running contacts are mounted in a molded contact block. Double break, movable contacts are attached to copper spanners, spring-mounted on an insulated rocker arm. In the starting position, the movable contacts bridge the motor and reduced voltage contacts. In the running position, they bridge the motor and line voltage contacts. Easily accessible for inspection.





CAN BE SUPPLIED WITH OIL-IMMERSED CONTACTS

For installations requiring oil-immersed contacts, Bulletin 646 Transformer-Type Starters can be supplied with an oil tank, inserted through the bottom of the enclosure. The tank is suspended on threaded studs, which serve as hangers when the tank is lowered. Since contacts immersed in oil deteriorate much more rapidly than when operated in air, air-break starters are preferable for most applications.



Allen-Bradley Co., 1316 S. Second St.
Milwaukee 4, Wis.

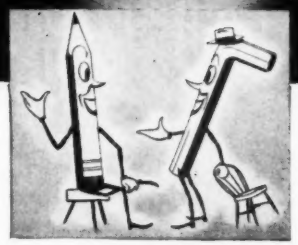
TURN
see front page

Send for Bulletin 646

ALLEN-BRADLEY

Reduced-Voltage Starters for Squirrel-Cage Motors

QUALITY



They both prefer Bristol's Socket Head Cap Screws

Pencil: "With Bristol's Socket Head Cap Screws, designs can be more *compact*—small pockets, narrower flanges, etc.—because of the internal wrenching."

Wrench: "It's easier for the assembly man, too—particularly in hard-to-get-at places."

Pencil: "Bristol's Socket Head Cap Screws mean *flush* surfaces for better appearance and safety."

Wrench: "They take the wrench without fumbling or slippage—no danger of skid marks on the work."

Pencil: "The Class 3 fit produces a *lock-tight* engagement in the hole."

Wrench: "Bristol's Socket Head Cap Screws are *knurled* for easier starting, and they spin easily into place, fitting perfectly."

Pencil: "The great strength of Bristol's special alloy steel, heat-treated, means they can be tightened beyond the point where screws normally loosen due to shock and vibration."

Wrench: "And Bristol's 5-step inspection means that every one is a *perfect* fastener."

Bristol's Socket Head Screws are made in cap and set styles . . . regular Hex and Multiple-Spline socket . . . National Fine and National Coarse Threads . . . sizes from No. 4 wire to 1 in. diam. . . . various metals and finishes. Carried in stock by top distributors everywhere. Also, special shapes. Send for Socket Screw Catalog, addressing THE BRISTOL COMPANY, Mill Supply Division, 121 Bristol Road, Waterbury 91, Conn.

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for maximum efficiency, safety and economy

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HERE IS a complete analysis of the problems of machine designing . . . an organized "plan-of-attack" that enables you to design safer, more economical, more efficient machines. Topic by topic, this manual considers such important machine design problems as the proper selection of materials—design methods of applying strength and deflection considerations—the evaluation of machine elements as fastenings—the best methods of selecting power-transmission units and their components . . . practical aids, hints and suggestions on everything from good form in making machine-design computations to the elimination of vibration. Making the book unique among machine design guides is its complete treatment of stress concentration . . . applicability—mitigation—determination—and design application.

Machine Design

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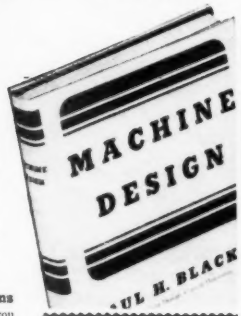
By PAUL H. BLACK
Prof. of Machine Design
Cornell University

334 pages 6 x 9 $4.00



Brings you the hard-to-find information you need to help you overcome many troublesome machine-design problems . . . the best methods for designing and selecting vibration absorbing units . . . methods of welding design . . . discussion of machine parts that have to be constructed with ready disconnection in mind. Here are the facts to consider in choosing materials; resistance to fatigue—hardness and ductability—the critical factor of machinability.

Design Approach to Gear Problems

This book emphasizes the important items you must consider in the designing of gears for industrial service . . . quietness and smoothness of operation—available gear-cutting equipment—the strength of teeth under static and dynamic loading. Discussed are spur and parallel helical gears . . . gears for non-parallel shafts . . . straight bevel gears, zero bevel gears, spiral bevel gears . . . the design and mounting of worm gearing and hundreds of other items on this important subject.

CONTENTS

- Materials and Processes
- Machine-Design Computations
- Loading and Induced Stresses
- Stress Concentration in Machine Members
- Allowable Stresses
- Members that Fail by Buckling
- Mechanical Fabrication
- Detachable Fastenings
- Springs-Pressure Cylinders
- Translation Screws
- Shafting
- Belt Drives and Hoists
- Power-transmission Chains
- Shaft Couplings
- Clutches and Brakes
- Spur and Parallel Helical Gears
- Gears for Nonparallel Shafts
- Surface Finish, Friction, and Wear
- Sliding Bearings and Lubrication
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- Vibration and Vibration Control

Special Features

★ Includes full treatment of stress concentration in machine members.
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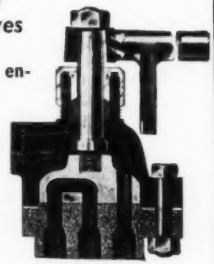
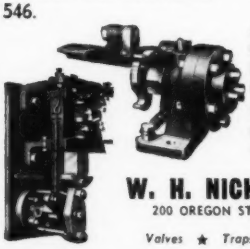


Types for most Operating Purposes



Above, lever model, ¼" to 2½", press. to 500 lbs.; others to 5000 lbs. Left, foot and solenoid models, ¼" to 2½", press. to 375 lbs. For all mediums.

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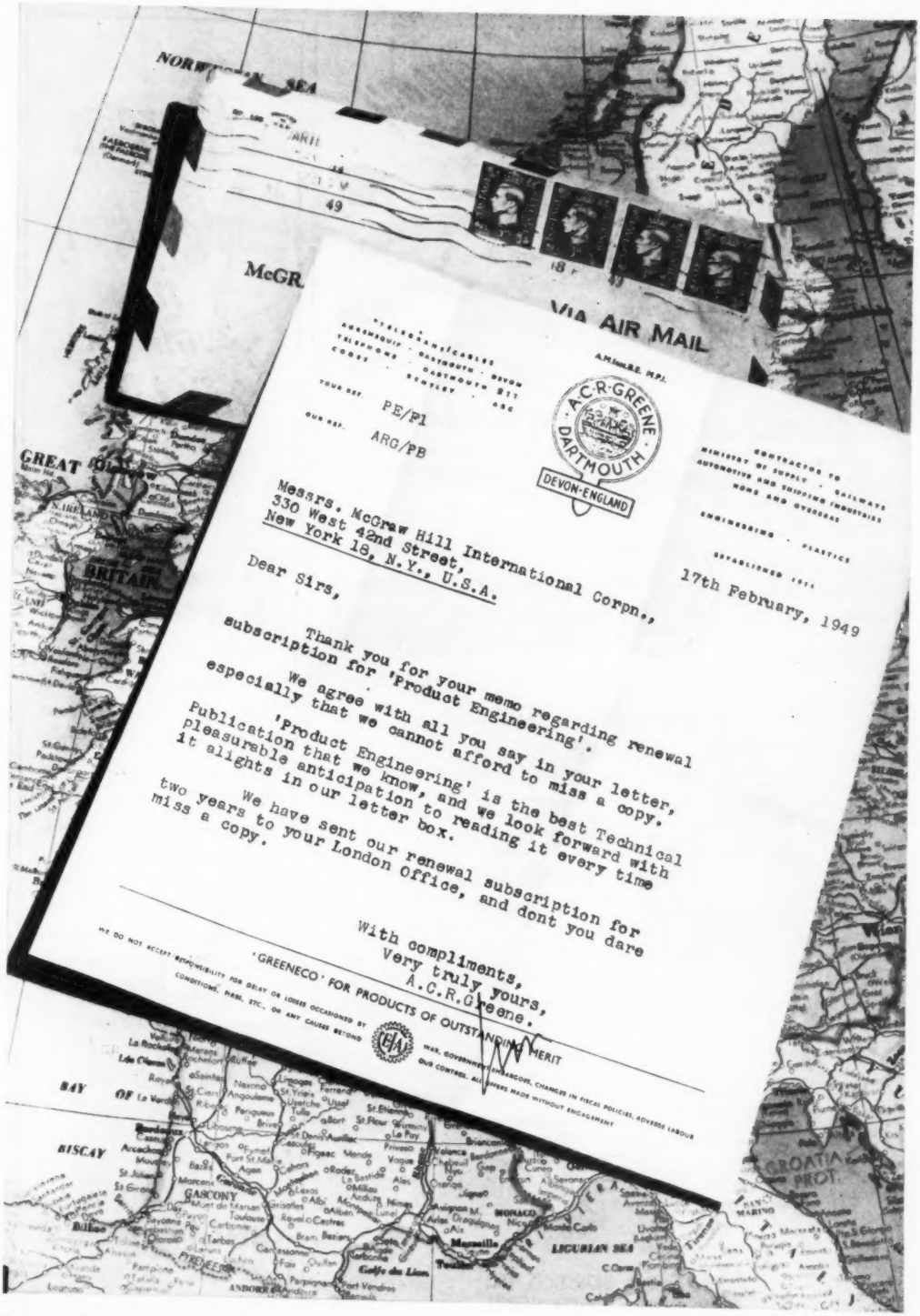
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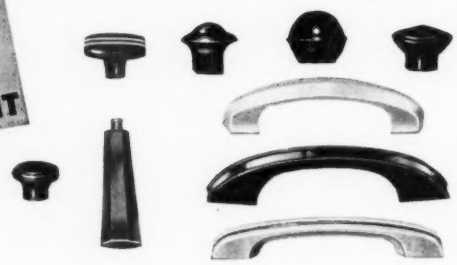

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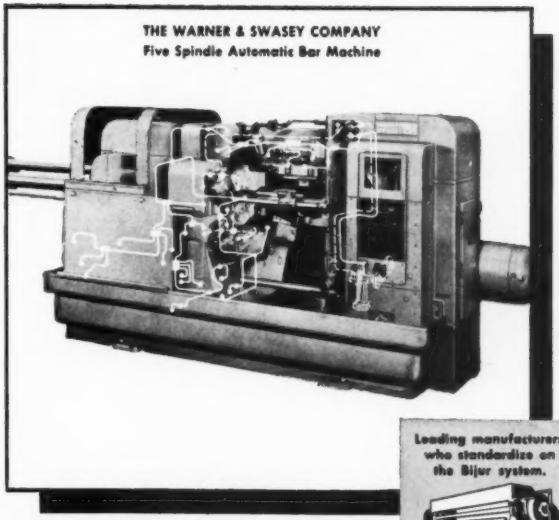
PRODUCT ENGINEERING

Your machines run smoother, longer...



...on bearings oiled by an automatic system of "metered" lubrication

Your machines run smoother, longer and continuously on Bijur-oiled bearings.

Smoother because the correct oil film is constantly maintained by meter-units at the bearings. *Longer* because overall bearing wear is considerably reduced by positive control of oil flow. *Continuously* because a Bijur-equipped machine oils itself while running, eliminating down-time for lubrication.

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Increased Production Output. A Bijur-lubricated machine oils itself while running, doing away with wasteful down-time for lubrication. Daily maintenance time is thus converted into more time for production.

Decreased Maintenance Costs. A Bijur-lubricated machine assures positive control of oil flow, considerably reducing bearing wear. Longer effective bearing life results in less down-time for repairs and maintenance.

If lubrication is your problem, why not call on the Bijur engineer, or write for "The Travels of Modern Lubrication." This quarterly bulletin shows how leading manufacturers protect performance and maintain production by using Bijur-lubricated machines.

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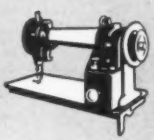

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and ON AMERICA'S FINEST GENERATORS

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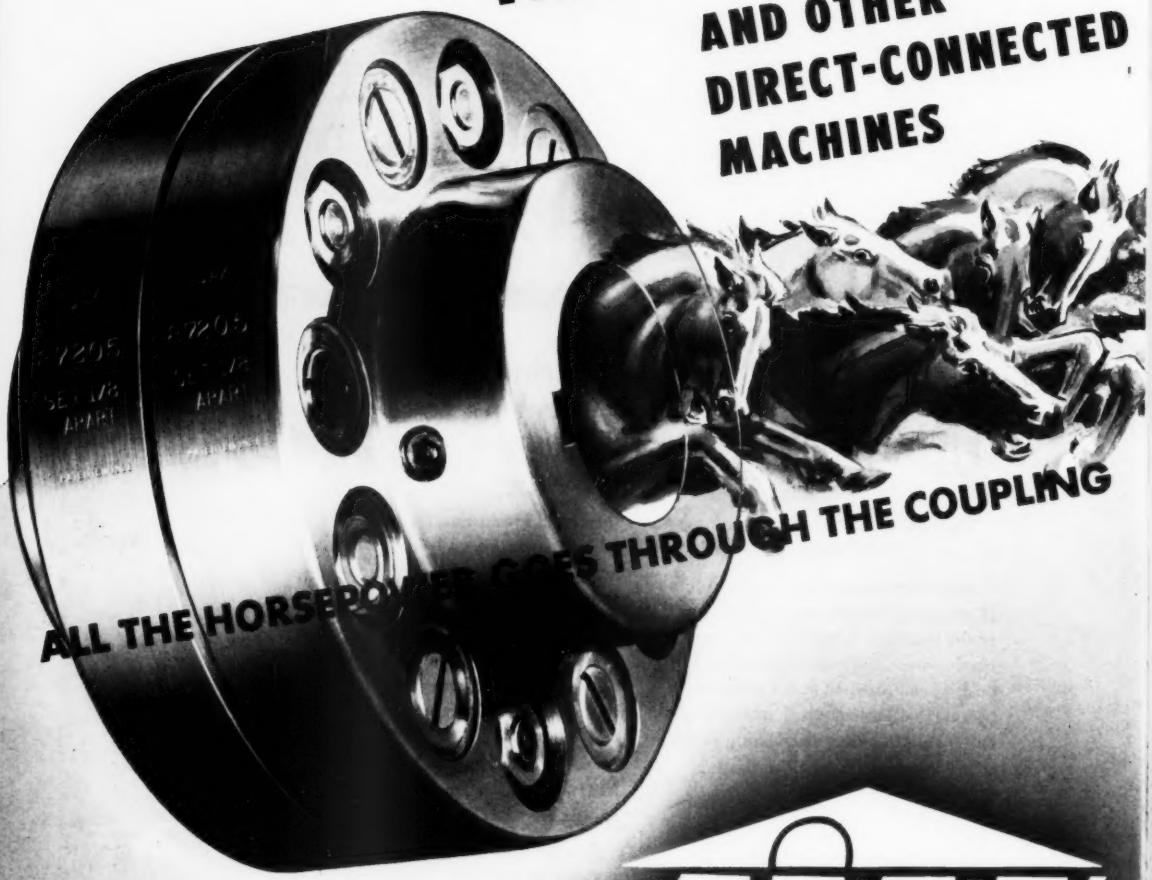

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Chrome Lock is a specially compounded and impregnated felt, containing zinc chromate as a corrosion inhibitor. Under low bolted or riveted pressures the resins traverse within the felt to form a positive dam.

On busses, for example, Chrome Lock tapes are widely used for sealing window sashes, skin laps and other faying surfaces. Chrome Lock offers advantages for *your* product, too!

LESS APPLICATION MAN HOURS: Chrome Lock's pressure sensitive adhesive back holds it in place, even on vertical or inverted surfaces. No tying, taping or cleanup. One-man operation. No odors. Non toxic.

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Leatherwood and other Masonite hardboards are low in cost and free of limitations found in so many alternate materials. You'll find it profitable to investigate. See our insert in Sweet's Product Design File.

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Please send me "Product Designer's Guide" and samples of Masonite hardboards, including Leatherwood.

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$7.50 Thermostat Replaces $250 Control Instrument ...and Eliminates Maintenance Costs!

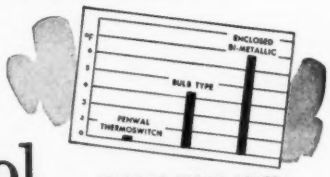

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Chart shows the change in the set point of a Thermoswitch* Control in comparison to two other types of thermostat when subjected to a mechanical shock of 100 G.

BECAUSE the Fenwal Thermoswitch* is *fast ... accurate ... rugged ... compact ... easily installed* ... and the contacts are *fully enclosed* by the temperature-sensitive shell!

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The Precision Thermostat For Temperature Control and Over-and-Under-Heat Detection
SENSITIVE ... *but only to heat*

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OTHER (Please fill in your special requirements) .....
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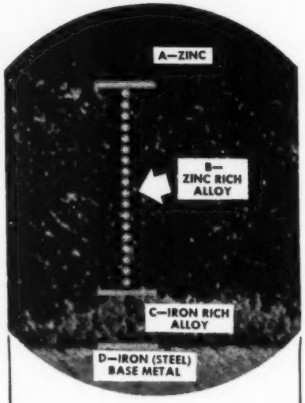
ONLY HOT-DIP GALVANIZING alloys molten zinc to base metal



The infallible testimony of the microscope reveals *why* the application of molten zinc through the *Hot-Dip Galvanizing process* provides the utmost in rust prevention. Protective zinc (A) is first *bonded* to the base metal (D) by an iron rich alloy (C)—then a layer of rich zinc alloy (B)—obtainable only through the Hot-Dip process—*seals out* destructive elements that cause rust and corrosion.

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Time has convincingly proved, by thousands of case histories, that the Hot-Dip Galvanizing method, as employed by members of this Association, *does* provide longer life, greater uninterrupted service and effects tremendous savings in expensive maintenance and replacement costs.

Write for Membership Roster

For membership roster or any information in regard to *your* particular corrosion problems, address The Secretary, American Hot Dip Galvanizers Association, Inc., First National Bank Bldg., Pittsburgh, Pa.

hot-dip GALVANIZING

One of a series *of messages to help you increase your understanding of business paper advertising, and its effect on your job.*

How advertising puts money in your pocket

WHEN YOUR COMPANY invests in a new machine, they can figure almost to the penny what they'll get back in better production.

By reducing the manufacturing cost per unit, the new machine increases your company's chance to earn a profit. Your workers can earn more because they're *producing* more. That's the only way your company can put more money into everybody's pocket – including yours.

The same principle applies to advertising.

For advertising works just like a machine. By mechanizing part of the selling process, advertising reduces the cost of *manufacturing a sale*. And that, too, means more money in everybody's pocket – including yours.

What does it take to "manufacture" a sale? Usually, there are five basic steps involved:

1. **Seeking out prospects**
2. **Arousing their interest**
3. **Creating a preference for your product**
4. **Making a specific proposal**
5. **Closing the order**

Any good salesman could handle all five. But no salesman should *have* to – not when advertising can perform the first three for him, and do them so much more *economically*.

Especially is this true of advertising in the business press. Nowhere else does the machinery of advertising operate so efficiently. Nowhere else does it go so far toward reducing the cost of manufacturing a sale!

PRODUCT ENGINEERING

is a member of The Associated Business Papers, who are sponsoring this campaign. If you'd like reprints of this advertisement, or the entire series, to pass along to others in your organization, we'll be glad to mail them to you.

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Use where ON-OFF operation is continuously repeated. The ON time and OFF time are each adjustable on the dial. (FLEXOPULSE)

MICROMETER DIAL

Provides exceptional timing accuracy where a circuit is to close or open with a time delay. Timing adjustable over wide range.

(MICROFLEX TIMER)

COUNTER

Use for limiting a process to an exact number of operations. The counter contact opens after 1 to 400 electrical impulses as selected on dial. Automatic spring reset.

(MICROFLEX COUNTER)

MULTIPLE CIRCUIT —ADJUSTABLE

Use where several circuits are to close in a predetermined sequence. Time of closing and opening each circuit is adjustable. (MULTIFLEX TIMER)

To reduce costs and improve quality of your products by automatic TIME-COUNT Control . . .

- ★ Write for catalogue Bul. 291.
- ★ Send for details of your control problems to Eagle for recommendations.
- ★ Consult Eagle representative in principal cities.

EAGLE Signal Corp.
MOLINE ILLINOIS

A 21-TON CASTING COULD BE A WHITE ELEPHANT

It takes considerable gumption to design a 20-ft. grinder bed. Many things could go wrong in casting such a monster. But the designer of this bed had confidence in our ability to cast it without distortion and structural defects—and that's what we did.

In many instances, ADVANCE CASTINGS are shipped considerable distances because our customers have found that it pays to go far for dependable foundry work. The cost of transportation—in fact, the entire cost of a casting—is insignificant compared to the extra machining costs which would be incurred in working up a casting that developed blow-holes, hard spots, sponginess, etc.

The character of our castings became widely known through *Strenes Metal* cast dies. We employ the same techniques in custom foundry work. If you want the evidence, write or phone us.

ADVANCE CASTINGS THE ADVANCE FOUNDRY CO. DAYTON 3, OHIO

STRENES METAL • ALLOY GRAY IRON • GRAY IRON

about

PRODUCT ENGINEERING'S

advertising pages...

In 1948, PRODUCT ENGINEERING again ranked among the first four of all industrial monthly magazines in advertising volume. Over 500 manufacturers used 3,286 advertising pages to tell you about their parts, materials, sub-assemblies or finishes . . . and how they can help you in designing better products to sell at lower prices.

This advertising is important to you . . . it brings you the latest available information on a host of product components that can help you to do a better job. And all during 1949 this advertising will continue . . . at a time when the return of the "buyer's market" lays particular stress on designing better products to sell at lower prices . . . to bring you the facts on how to do it, and what to do it with.

PRODUCT ENGINEERING

The Inside Story of a Pinched Penny

THERE is no economy in a cheap gear. On the contrary, a pinched penny may purchase untold expense—plus headaches without number.

That is why we specialize in gears—"Double Diamonds"—that possess *true* economy. Economy expressed in terms of lowest *final cost*—including installation *and* performance.

It takes a little more time to make "Double Diamonds"—and considerably more experience, care and skill. But when they're done, we're proud of them. And because they contribute so substantially to the life, the performance, and the continued efficiency of your product, you'll be proud of them, too.

Manufacturers interested in gears that are built to show lowest final cost—who have an eye for long-run economy—are requested to write for information.

DOUBLE DIAMOND TRADE MARK GEARS

Made by

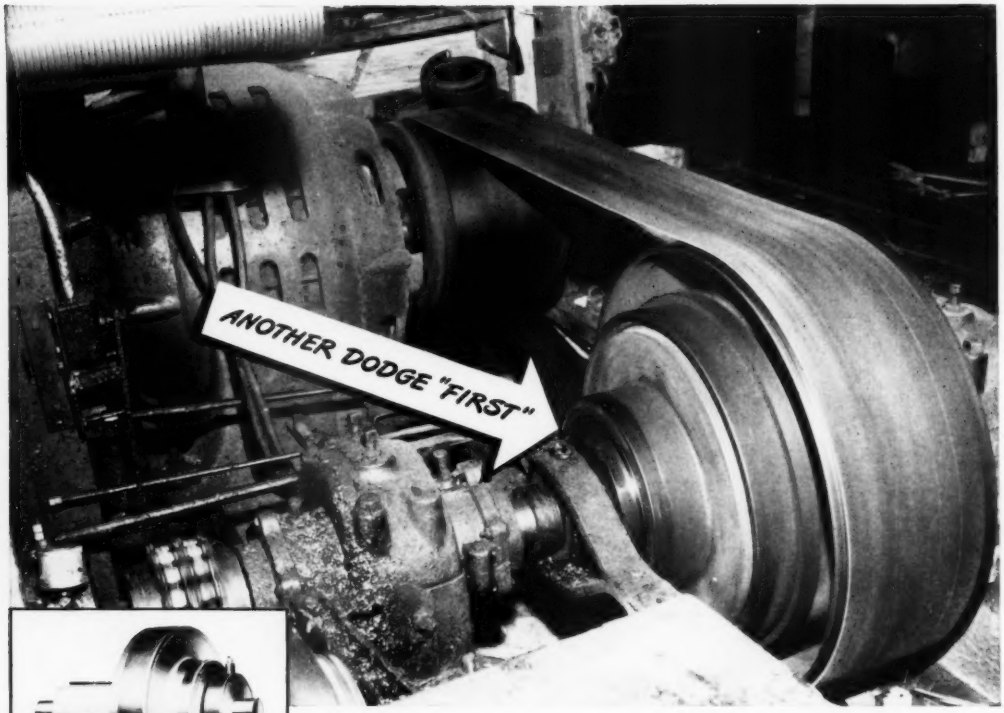
Automotive Gear Works, Inc.

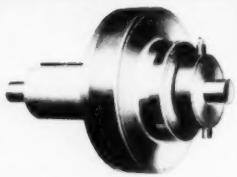
RICHMOND, INDIANA

• • • • • FOR AUTOMOTIVE FARM EQUIPMENT AND GENERAL INDUSTRIAL APPLICATIONS • • • • •

*Reg. U. S. Pat. Off.

HYPOID BEVEL · SPIRAL BEVEL · FLYWHEEL GEAR · ZEROL® BEVEL · STRAIGHT BEVEL · STRAIGHT SPUR · HELICAL SPUR · SPLINE SHAFT





Over 50 years of experience in the manufacture of industrial clutches have gone into the development of the famous Dodge Diamond D Friction Clutch — noted for its ruggedness and simple, one-point adjustment.

"SHOCK" TROUBLE?

Here's one way to lick it!

HERE A Dodge Diamond D Clutch takes the tremendous shock loads of a veneer peeler lathe. Huge logs are revolved and "peeled" by knives, with 150 to 200 engagements per hour! Precision-built clutches, capable of performing dependably where profits depend upon uninterrupted operation, are another Dodge "first" — one of many Dodge "firsts" in the field of power transmission machinery.

For information on how Dodge products can improve machine performance, save power and keep production steady, call the Transmissioneer, your local Dodge Distributor. He has information on new and better developments for the mechanical transmission of power.

DODGE MANUFACTURING CORPORATION • MISHAWAKA, INDIANA

TAPER-LOCK SHEAVE
Simplest, surest mechanism ever devised for holding wheels to shafts.

DODGE-TIMKEN BEARINGS
save power on millions of industry's toughest jobs.

ROLLING GRIP CLUTCH
No toggles! Compact. Extreme flexibility with positive drive.

TAPER-LOCK FLEXIBLE COUPLING
Available from stock ready to install *without reboring!*

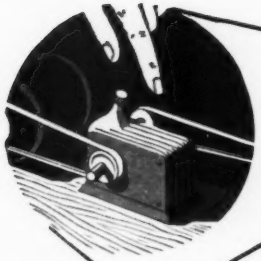
FIRST IN POWER TRANSMISSION MACHINERY!

DODGE
of Mishawaka, Ind.

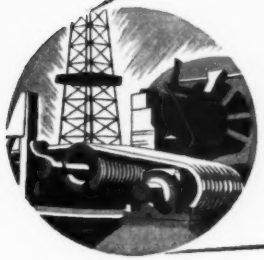
CALL THE TRANSMISSIONEER
– graduate of a Dodge factory course, qualified to help on your power transmission problems. Look for his name under "Power Transmission Equipment" in your classified telephone book

NAME PLATES

FOR YOUR NAME PLATE REQUIREMENTS, WRITE OUR SUBSIDIARY, ETCHING COMPANY OF AMERICA, 1520 MONTANA STREET, CHICAGO 14, ILLINOIS



Do You Have a Problem in TURNING WHEELS?



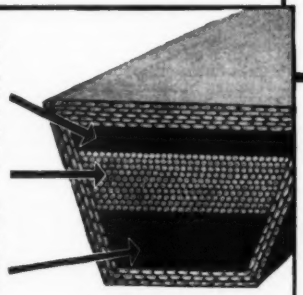
Maybe you have a job that you never dreamed could be done with a V-belt. Perhaps we at U. S. Rubber can help—we are constantly solving such problems . . . sometimes by designing V-belts which help safeguard human life—on submarines, for example.

U. S. Rubber engineers have designed a V-belt as small as 4¾ inches in circumference, and as large as 55 feet. They have solved such a wide range of V-belt problems that today, if you want "a special" in a hurry, chances are it can be obtained without making a new mold.

For more information, write Mechanical Goods Division, United States Rubber Company, 1230 Avenue of the Americas, New York 20, N. Y.

U. S. RAINBOW V-BELTS

WITH THE EQUA-TENSIL CORD SECTION



Top Rubber Cushion in closely-engineered balance with the lower section . . . to keep cool under constant stretch and turn.

Equa-Tensil Cord Section —all cords scientifically placed, each pulling its share of the load.

A sturdy level cushion for the Equa-Tensil Cord Section. Provides structural firmness for V-grooves and over the flat pulley of V-to-flat drives.

MADE BY

U.S.RUBBER

SERVING THROUGH SCIENCE

UNITED STATES RUBBER COMPANY

NEW LIGHTWEIGHT PIPE WRENCH

another triumph for

FRONTIER 40-E ALUMINUM ALLOY!

A sturdy new aluminum pipe wrench that meets highest specifications for usage, yet weighs *less than half* as much as the ordinary-type wrench—that's the newest successful application of Frontier 40-E Aluminum Alloy.*

Produced as a cast wrench by the Frontier Bronze Company, the new product has all the wear-resisting qualities inherent in Frontier 40-E—the non-heat-treated aluminum alloy which has given superior performance in so many industrial and commercial uses.

LIGHTWEIGHT
Picture clearly shows lightweight feature of new FRONTIER Aluminum Wrench

Whatever the product—from hand tools to large-size equipment—if ALUMINUM can do the job better, 40-E ALUMINUM ALLOY can do it best!

STURDY
FRONTIER wrench stands up under heavy usage, as graphically illustrated here, with 215-lb. man exerting full pressure 40" from wrench jaws.

● The FRONTIER Wrench exceeds Government specifications (GGG-W-651a) for pipe wrenches. It is guaranteed against breakage in normal use.

←*Write for Booklet!*

Write today for Frontier Alloy Data Book which gives pertinent engineering and metallurgical facts about Frontier 40-E Aluminum Alloy.

FRONTIER BRONZE CORPORATION

4881 Packard Road, Niagara Falls, N. Y.

3265

SEE—TEST—FEEL *the LATEST Developments in* GASKET, WASHER *and* SEALING materials

FREE GUIDE *brings you* over **50** ACTUAL SAMPLES!

If you manufacture products employing gaskets, washers, seals, sound-deadening materials, dampening materials, dielectrics, etc., this GUIDE TO BETTER SEALING will be sent to you without cost or obligation.

The GUIDE contains 50 actual samples of the most commonly-used sealing materials, which Fel-Pro supplies to such leading companies as American Can, Baldwin Locomotive, DuPont, General Electric, Packard, Pure Oil, Quaker Oats, Standard Oil, Western Electric and Westinghouse.

TEST THEM YOURSELF
FEL-PRO'S GUIDE TO BETTER SEALING makes it possible for you to closely inspect a wide range of materials, test them under all kinds of conditions in your own plant, treat them chemically or make any other tests to help you decide which are best suited for your particular needs.

GIVES FULL SPECIFICATIONS
Among the sample materials contained in this SEALING GUIDE are such newly-developed materials as the revolutionary "Fel-Pro 131". This material is particularly suited to automotive engine parts, chassis parts, pumps, high compression flanges, etc., because of its low swell (just 2%) and exceptional durometer hardness of up to 80 plus or minus 5. Complete specifications are given for each of the 50 material samples, including durometer readings, sheet and roll sizes, applications, etc.

PARTIAL CONTENTS
Felbestos 100 for manifold and hot-spot applications!
Metallic Gasket Materials!
Fel-Pro 131 the new low-cost rubber!
Karropak treated to maintain uniformity!
Fel-Pak for water, oil, etc., connections!
Kork-Karro for use between metal and non-metal surfaces!

SEND TODAY
To get your FREE copy of the FEL-PRO GUIDE TO BETTER SEALING without obligation, just write your name and title on your company letterhead and mail to: Felt Products Mfg. Co., 1534 Carroll Avenue, Chicago 7, Illinois.

LOOK TO
FEL-PRO
for the LATEST in sealing materials

ALUMINUM CLIPS & CLAMPS NOW CHEAPER THAN STEEL!

Steel prices have risen to such heights that you can now get aluminum clips and clamps at lower cost than steel! Unit material costs are comparative and aluminum processing is considerably faster. Add to this your faster assembly time and lower shipping expense and the total savings are impressive. Send for new bulletin giving analysis of comparative costs. Sample clamps will be submitted for your inspection.

Wide range of types and sizes, bare metal and cushioned. Send for catalog and free draftsmans tracing sheets.

Stainless Steel Clamps — Standard sizes now in stock for immediate shipment. Quick deliveries on specials. Stainless recommended for installations requiring extra high heat and corrosion resistance.

New ⅜" Line in Stock — in aluminum, steel and stainless—Bare metal and cushioned (AMS 3209 Neoprene) clamps in sizes from ⅛" to 1" in 1/16" diam. increments.

World's largest producers of AN742 and AN743. Manufacturers of over 2500 types and sizes of aircraft and industrial clips, clamps and blocks.

THOMAS ASSOCIATES

4609 Alger St., Los Angeles 26, Calif. CHapman 5-3748

West's Culture Assailed As Soviet Schools Open
LONDON, Sept. 1—A new school year began in Russia today and Pravda, the Communist party newspaper, exhorted teachers to fill their students with "profound contempt for bowing and scraping before the bourgeois culture of the West."
A Pravda editorial, broadcast by the Moscow radio, said teachers had failed in the past to "reveal the advantages of the Socialist system" in history and geography lessons. It charged the teachers with "passing over in silence the priority of inventions and discoveries by Russian scientists."

Dear Soviet Teachers:

We note that you have been discreetly silent on some aspects of the Communist system. And that you have been urged by Pravda to fill your students with "profound contempt" for the admiration given to ours.

May we respectfully suggest a few more things that you'd better keep quiet about if you want the young Russians to grow up convinced Communists.

Don't tell them that in America the opportunity for advancement is unlimited—that here a man can work where he pleases and change his job when he pleases, and that he has the right to organize and bargain collectively.

Don't say anything about the competitive system, with rewards for initiative and enterprise in free markets—the same system which has produced a standard of living about ten times higher than yours.

Don't mention that here people can own things and manage their own businesses . . . and invest money in new undertakings.

Don't breathe a word about the American urge to invent better machines—and more productive ways to use them.

Don't refer to a dynamic way of life that keeps on turning out more and better goods—keeps on lowering costs and raising wages, with shorter working hours.

In other words, don't give them any of the facts about what happens when free people, governing themselves and spurred by ambition, go all-out to build a new kind of country—different from any the world has ever seen.

We don't say our way is perfect—far from it. We still have our ups and downs of prices and jobs. But we *know* what's wrong and we're free to *do* something about it. Change is our middle name. *And in the long run, our system always changes for the better.*

P.S. About that "priority of inventions," the point isn't whether the Russian scientist Lodygin invented electric light before Edison, but what happened *after* it was invented. Which system—yours or ours—has mass-produced for more people the daily benefits of such inventions as the automobile, telephone, radio, refrigeration, central heating, modern plumbing and better farm machinery? The world knows that it is *our* system!

John Q. Public, U. S. A.

THE BETTER WE PRODUCE, THE BETTER WE LIVE

Approved for the PUBLIC POLICY COMMITTEE *of the Advertising Council by representatives of Management, Labor and the Public:*

EVANS CLARK
Executive Director
Twentieth Century Fund

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American Federation of Labor

Published in the public interest by

PRODUCT ENGINEERING

FREE! Send for this valuable booklet today:

In words and pictures, it tells you
—How our U. S. Economic System started
—Why Americans enjoy the world's highest standard of living
—Why we take progress for granted
—How mass production began
—How we have been able to raise wages and shorten working hours
—Why more Americans have jobs than ever before
—Why the mainspring of our system is productivity
—How a still better living can be had for all

MAIL THE COUPON to Public Policy Committee, The Advertising Council, Inc., 25 West 45th St., New York 19, N. Y.

NAME_____

ADDRESS_____

OCCUPATION_____

highlights *of*

June's special report on designing for lower costs

●

General Principles of Redesigning for Lower Costs

An introductory article by the PRODUCT ENGINEERING editors summarizing: factors to be considered when seeking cost reductions; procedures for estimating what cost reductions **can** be achieved; how to accomplish desired cost reductions through engineering and production advances.

Case Histories

200 actual examples of how cost reductions have already been achieved. This section will be profusely illustrated and reading text will be largely confined to captions, charts, and tables.

Cost Charts and Curves

Through one of the mediums design engineers like and find most useful, the June issue will present detailed statistics on the relative values and applications of all types of mechanical and electrical parts, and on materials, sub-assemblies, and finishes.

The Old . . . and the New

Conceived by the editorial staff, and executed by the McGraw-Hill Technical Illustration Department . . . this unique section will consist of new product designs superimposed over the older designs, so that specific methods for achieving lower-cost designs can be quickly compared with former, less efficient methods.

●

be sure you see the answers on how to bring costs down in

JUNE'S PRODUCT ENGINEERING

TESTED PATH

DIEFENDORF travels the production path that assures gear efficiency for each particular job. Gears cut to manufacturer's specifications. Quantity production. Gear design. Repairs and replacement. Gears of all types —all materials.

DIEFENDORF GEAR CORPORATION

Syracuse 1, NEW YORK

DIEFENDORF GEARS

The famous Type "E"...so popular in the ¾", 1" and 1" pipe sizes, is now complete with 1¼", 1½" and 2" pipe sizes. Its ALL-BRONZE CONSTRUCTION and screwed-in seats, as well as Nycar seat washers and Neoprene diaphragm, mean a LONG LIFE of TROUBLE-FREE service on those big jobs you put in.

Sold ONLY through plumbing and heating wholesalers. See them. . . . Ask for . . . .

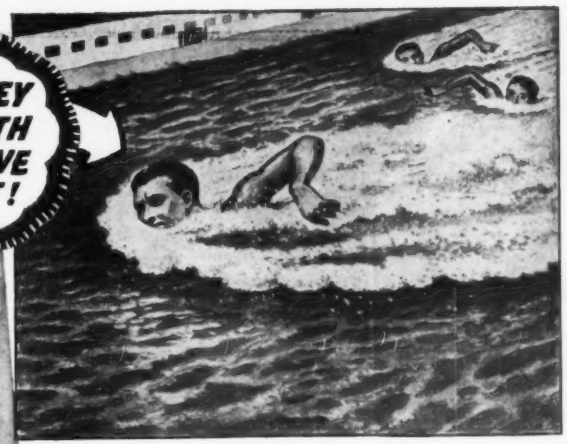
Write for your free copy of our new 1948 Catalog for complete details on CASH-ACME Products.

CASH-ACME *Automatic Valves*

A.W. CASH VALVE MANUFACTURING CORPORATION

6662 EAST WABASH AVENUE DECATUR, ILLINOIS, U. S. A.

The "EXTRA SOMETHING" that spells TOP PERFORMANCE



Seletron
SELENIUM RECTIFIERS

SLASHING his way to victory by powerful, telling strokes, the swimming champion is first at the finish line by a safe margin — a winner because he has the "extra something" in skill and endurance that spells TOP PERFORMANCE.

Top performance in every rectifier application is assured to users of Seletron Selenium Rectifiers by reason of the "Extra Something" we put into them.

All chemicals of high purity to meet rigid special specifications.

Precision methods in all mechanical and chemical processes plus scrupulous care in assembling give them "Extra Something No. 2."

And to clinch all, every Seletron Selenium Rectifier must pass through an uncompromising series of tests and inspections, before we give it our OK for shipment to you.

Fabricated under such rigid rules, it is easy to understand why Seletron Rectifiers have won a nation-wide reputation for long dependable service in AC to DC applications of every type.

FOR ALL ELECTRONIC AND RADIO APPLICATIONS SPECIFY "SELETRON MINIATURES".
They insure dependable service.

CODE NUMBER	5M4	5M1	5P1	5R1	5Q1	5S1
Current Rating	75 ma.	100 ma.	150 ma.	200 ma.	250 ma.	500 ma.
Plate Height	1"	1"	13/16"	1 1/2"	1 1/2"	2"
Plate Width	1"	1"	13/16"	1 1/4"	1 1/2"	2"

Furnished in a variety of assemblies to cover a wide range of currents and voltages.

1949 IS TV YEAR

Write today for Catalog. Address Dept. PS-17

SELETRON DIVISION
RADIO RECEPTOR COMPANY, INC.
Since 1922 in Radio and Electronics
251 WEST 19TH STREET, NEW YORK 11, N. Y.

Anti-Corrosive
STAINLESS STEEL FASTENINGS DO THE JOB Better

Every Day More Stainless Fastenings Appear in the Industrial Picture!

This year more stainless fastenings will be used by industry than ever before, because every day industry discovers another spot where stainless works better! Whether your fastening problem calls for superior strength . . . corrosion resistance . . . non-magnetic quality . . . permanence . . . resistance to heat or cold . . . re-use quality . . . shock or vibration resistance . . . or fine appearance . . . *count on stainless for the answer!* And count on Anti-Corrosive to have just the fastening you need!

At Your Fingertips . . . the Largest Stainless Fastening Stock to Be Found Anywhere!

Over 7,000 varieties of stainless fastenings *on hand*, ranging from a #0 machine screw to a 2" nut, ⅜" washer to a 24" construction bolt. Call on Anti-Corrosive first . . . America's oldest and largest supplier dealing *exclusively* in stainless steel fastenings. An outstanding special order service is also available for the occasional item not found in stock.

Ask Your Secretary to Write for Folder F-49 for the Latest Information on Stainless Fastenings . . . TODAY!

Anti-Corrosive Metal Products Co., Inc.
Manufacturers of STAINLESS STEEL FASTENINGS
CASTLETON-ON-HUDSON, NEW YORK

ONE ISSUE... 10,000 MILES

If you've ever wondered how PRODUCT ENGINEERING's editors manage to bring you all the information they do, one answer lies in the time these editors spend in the field, talking to design engineers throughout industry.

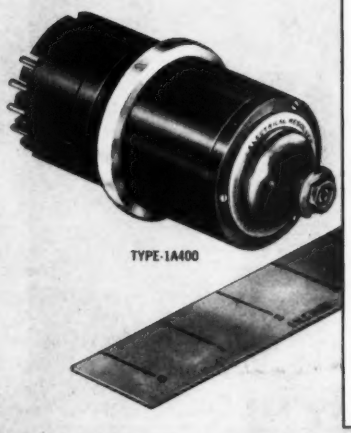
In June, for example, PRODUCT ENGINEERING will explore the subject of "Designing for Lower Costs." And no subject as important as this can be *thoroughly* explored from the narrow confines of an editorial office.

So our editors are already taking to the road . . . to talk and compare notes and ideas with the men who are sparking industry's drive for lower costs. They will have travelled over 10,000 miles before they're through. And when you sit down in June with this special issue of PRODUCT ENGINEERING, it will be, in a sense, just like taking off, yourself, on a nation-wide trip that would take you into most of the engineering departments of the companies which lead America's continual quest for better products for more people at prices *all* people can afford to pay.

o

PRODUCT ENGINEERING

To Top-Flight Development, Design and Instrumentation Engineers:



The accompanying table gives the characteristics of Arma Electrical Resolvers. The accuracy of these components is indicated by the tolerances in transformation ratio (S/P), phase shift, and angular accuracy.

TYPE	FREQ.	IN-PUTS	OUT-PUTS	INPUT VOLTAGE	RATIO (S/P)	PHASE SHIFT	REQUIRED AUXILIARY UNITS
E	60	1	2	8	0.9750 ±.0010	6'20' ±5'	Compensator
N	60	2	2	8			Two Compensators
J	60	1	2	0.5-16	0.989 ±.015	4°35' ±60'	None
K	60	2	2				None
1A400	400 ±10%	1	2	0.5-16	1.0000 ±.0006	0°0'±3'	Booster Amplifier
1B400		2	2	0.5-16			
1C400		1	1	0.5-16			
1D400		2	1	0.5-16			
P	400	2	2	0.5-16	0.98 ± .02	75'±20'	None

Maximum Angular Inaccuracy Is 0.1% x (S/P) x Input Voltage
Operating Temperature Range for All Resolvers = 0° to 55° C
**One Booster Amplifier may be used for two (2) Resolvers of this type.*

New Approaches to New Horizons Are Opened by These Resolvers*...

They offer an accurate and dependable means of solving problems involving the trigonometric functions . . . for applications in electromechanical computing and control equipment . . . until recently highly restricted.

Arma Resolvers Are Computing Components

The Arma Electrical Resolver is an electromagnetic unit designed to deliver two alternating voltages proportional respectively to e_1 sin A plus e_2 cos A and e_1 cos A minus e_2 sin A, where e_1 and e_2 are the voltages applied to the two primaries and A is the angle through which the rotor has been turned from the position defined as electrical zero.

They Solve Problems Involving Triangles, Coordinates, Vectors

Problems such as the rotation of coordinates, solution of triangles for angles or sides, addition of angles, transfer between rectangular and polar coordinates, and the resolution, composition or addition of vectors are readily solved using Arma Electrical Resolvers. Angular inaccuracy defined in terms of difference between actual and theoretical output voltages for any rotor position is always less than 0.1% of (S/P) x input voltage.

The Results are Fast and Accurate

Arma Electrical Resolvers may be regarded as high-precision signal transformers with continuously variable ratio. In common with other electromagnetic devices there are changes in the inherent transformation ratio and phase shift caused by changes in frequency, temperature or primary voltage. Arma resolver design recognizes these factors and gives results of extreme accuracy.

Advantages of Arma Resolvers Over Wire-Wound (Potentiometer Type) Units

1. *Stepless operation — outputs are smooth accurate sine or cosine functions uninterrupted by "wire stepping."*
2. *Unlimited rotation with no circuit interruptions.*
3. *No wear; indefinite life with no change in accuracy.*

Use These Other Arma Components, Too

Here are possible applications of other Arma components released for private industry which invite interest: Tachometer-type Induction Generators for high performance servo systems; two-phase Induction Motors for servo mechanisms and control devices; Synchro Units (better than Navy "Specs") for remote control and indicating purposes; high-precision Mechanical Differentials for computer applications.

How Ideas Become Realities

For over 30 years Arma Corporation has been quietly taking on (under wraps) one complex development and design problem after another for the U. S. military establishments—problems concerned with instrumentation. In the initial stage these problems may be little more than a gleam in someone's eye, a vague hope, a "dream"! That's where Arma *starts*.

When Arma *finishes*, the problem is not only solved but the actual equipment to do the job, *built*—whether it be a complicated gun director, a gyro compass or a complex remote control system. Arma follows through to practical realities.

You are invited to request whatever information you may need to explore the possibilities of making use of any Arma product which has been released from security restrictions.

ARMA CORPORATION

254 36th STREET, BROOKLYN 32, N. Y.

SUBSIDIARY OF AMERICAN BOSCH CORPORATION

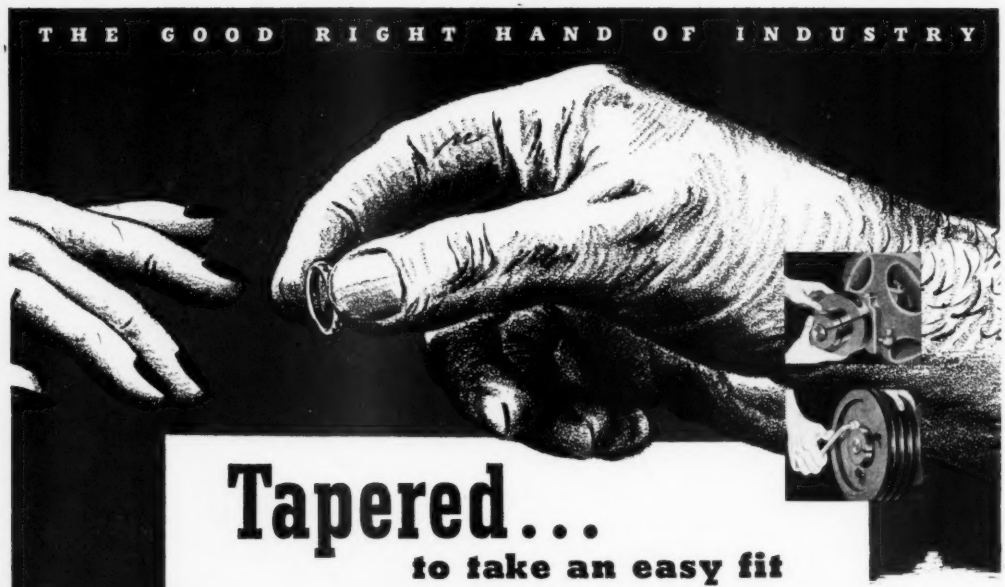
ARMA PRODUCTS RELEASED FOR PRIVATE INDUSTRY

ARMA ELECTRICAL RESOLVERS* · ARMA SYNCHROS · ARMA INDUCTION MOTORS · ARMA INDUCTION GENERATORS · ARMA MECHANICAL DIFFERENTIALS · ARMA ALTERNATING VOLTAGE COMPARATOR · COMPUTING MECHANISMS · INDUSTRIAL CONTROLS · STABILIZATION DEVICES · NAVIGATIONAL EQUIPMENT · LIMITRON AUTOMATIC INSPECTION SYSTEM

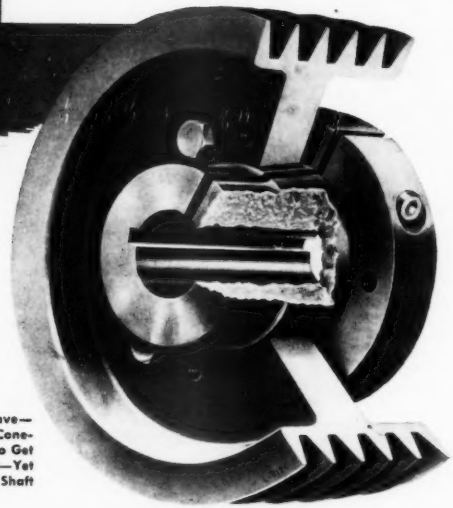
* Licensed for use under Arma patents Nos. 2,465,624 and 2,467,646. License information available.

QUALITY ARMA INSTRUMENT PRECISION

THE GOOD RIGHT HAND OF INDUSTRY



Tapered...
to take an easy fit



Worthington QD Sheave—Original Tapered Cone-Grip Sheave. Easy to Get On—Easy to Get Off—Yet Always Tight on the Shaft

The tapered mating of the two-piece QD Sheave makes Worthington's Multi-V-Drive an attractive sales point for your equipment.

It's the easiest sheave to install because the lightweight split hub goes on first . . . is locked in place . . . then the tapered-bore rim slides over the tapered-cone hub . . . is pulled up by full-sized bolts.

Easy as this is, the QD *stays tight* on the shaft. The cone-friction grip on the hub produces a positive press fit on the shaft. The QD clamps the shaft tighter than any other sheave on the market!

For Balanced Drive Performance

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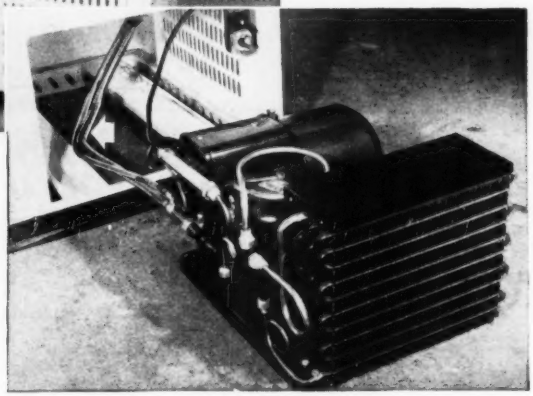

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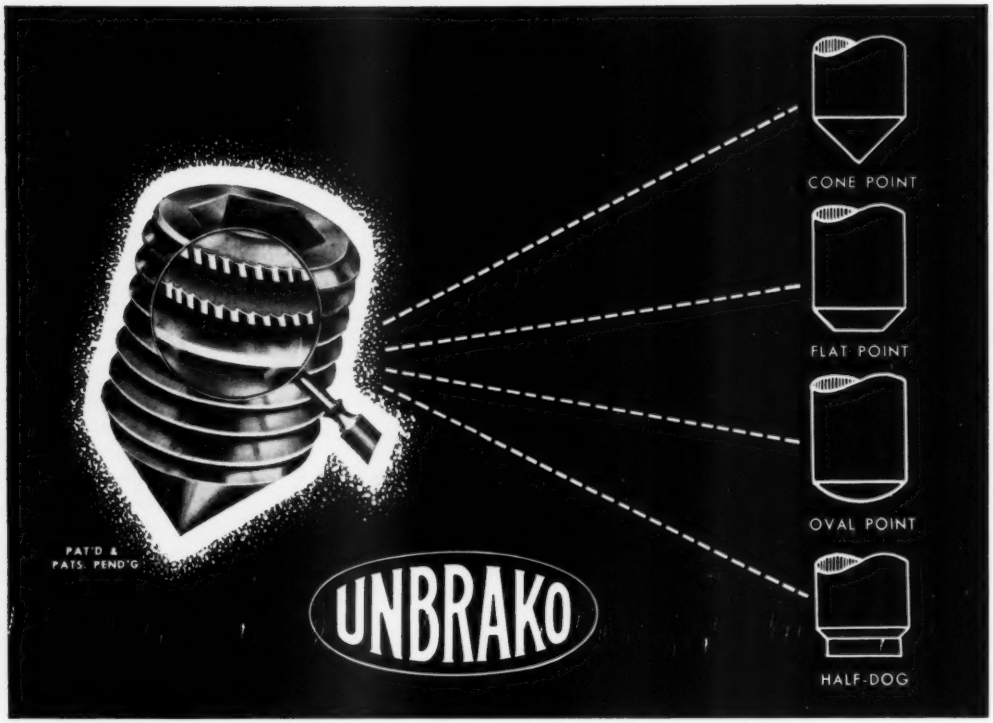

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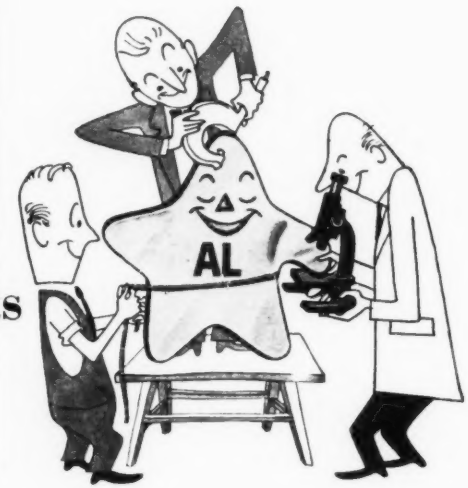
BUSINESS OPPORTUNITIES
Offered 335

There's only one family of Stainless Steels that will meet all your requirements



ALLEGHENY METAL is the *only* stainless steel that is produced in every commercial grade and finish—and more especially, in every shape or form that a fabricator may need.

From *one* source, therefore, you can get everything . . . sheets, strip, plates, bars, wire, shapes, fine wire, tubes, castings or forgings—in the type of stainless steel that the service conditions require. What's more, you can get it *now* . . . Allegheny Metal is promptly available to your order.

Use this convenient, one-stop source of supply for stainless steel—the clean, strong, shining metal that's cheapest in the long run because it *lasts* longest. ● When you're in the market for stainless, think first of Allegheny Metal.

W&D 2342 *Complete technical and fabricating data—engineering help, too—yours for the asking.*

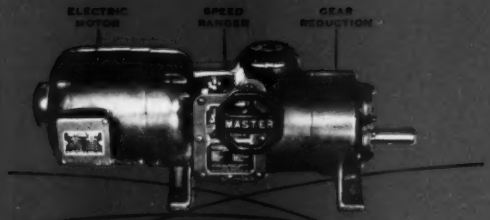
ALLEGHENY LUDLUM STEEL CORPORATION

The Nation's Leading Producer of Stainless Steel in All Forms

AL

Pittsburgh, Pa. . . . Offices in Principal Cities

Allegheny Metal is stocked by all Jos. T. Ryerson & Son, Inc., Warehouses



On thousands of applications, stepless variable speed operation assures exactly the right speed for every operation . . . for each operator . . . the right speeds for each change in the consistency or shape of the material being processed. Such variable speed operation gives you plus value in higher rates of production, a better quality product and more efficient performance of your equipment and your operators.

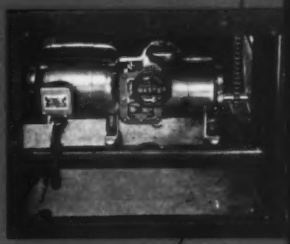
Master Speedrangers provide this infinitely variable speed in compact, all-metal, mechanical variable speed units in a wide range of types and in sizes up to 5 horsepower.

variable speed operation offers you PLUS VALUE

For example, see how the Speedranger on this Rockwell packaging machine incorporates an electric motor, a variable speed unit and a gear reduction unit . . . all standard Master units that easily combine into a compact, integral power package. This provides exactly the RIGHT horsepower, the RIGHT range of speed, the RIGHT features, in a unit that you can use RIGHT where you want it.

Write for Data 7525, a new 24-page book on Speedrangers, and see what a real job they can do for you.

THE MASTER ELECTRIC COMPANY • DAYTON 1, OHIO



The all-metal construction of Master Speedrangers adds greatly to the compactness and durability of the job.

MASTER SPEEDRANGERS

Production of new TIMKEN® "00" bearing being increased to meet demand!

...opens the way to new standards of accuracy in high precision applications!

Only a few short months ago, The Timken Roller Bearing Company announced a new bearing—the "Double-Zero"—*twice as accurate* as any Timken® bearing previously produced.

And already the new Timken "Double-Zero" bearing, with a run-out tolerance of only 75 millionths of an inch, is raising standards of accuracy in high-speed lathe spindles, grinding machine work heads, gear cutting machines, small precision rolling mills, and other precision applications. And production of the "Double-Zero" is being increased to meet the growing demand.

The extreme accuracy of the "Double-Zero" bearing results from the use of measuring devices of extreme accuracy, specialized machine tools, and improved manufacturing methods.

The new "Double-Zero" bearing is the latest example of Timken leadership in serving the bearing needs of all industry—another reason why it pays to look for the trade-mark "Timken" on every tapered roller bearing you use. For further information write The Timken Roller Bearing Company, Canton 6, Ohio. Cable address: "TIMROSCO".

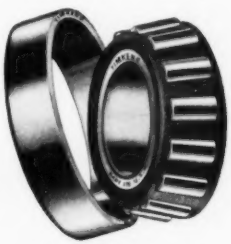
This symbol on a product means its bearings are the best.

A PRECISION TIMKEN BEARING FOR EVERY REQUIREMENT			
CLASS	**"00" (DOUBLE-ZERO)**	**"0" (ZERO)**	**"3" (THREE)**
RUN-OUT	.000075"	.000150"	.000300"
TYPES AVAILABLE	Standard Single Row	Standard Single Row	All types
SIZE RANGE	Up to 10" O.D.	Up to 12" O.D.	Up to 12" O.D.

TIMKEN

TRADE-MARK REG. U. S. PAT. OFF.

TAPERED ROLLER BEARINGS



NOT JUST A BALL ○ NOT JUST A ROLLER ▭ THE TIMKEN TAPERED ROLLER ▭ BEARING TAKES RADIAL ◫ AND THRUST ◫ LOADS OR ANY COMBINATION ◫